

SCIENCE

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THE WIDDIFIELD AND BOWMAN ELECTRIC CAR-BRAKE.

AMONG the brakes tried at the Burlington brake tests in 1886, was that invented by Mr. W. P. Widdifield and A. T. Button of Uxbridge, Ontario, Can., who had a train of fifty cars equipped with their "independent momentum brake." At those tests it was demonstrated that this brake, in common with all of its competitors, developed very objectionable shocks at the rear end of long trains, owing to the fact that the brake-power could not be transmitted to the rear car quickly enough to prevent the concussion of the cars closing together. The inventors have now overcome this

working contact with the axle-pulley *C*. The pulley *e* immediately rotates, winding on its axle the chain *v*, which, through compound levers, *w* and *r*, brings the large friction-wheel *d* in frictional contact with the axle-pulley *c*, and causing it to rotate and wind upon its axle the power brake chain *s*.

Only a momentary impulse of electricity is required to apply the brake by turning the switches *Z'* or *Z''*, as the armatures of the brake-magnets are provided with a ratchet bar and pawl, *l* and *m*, which catch and hold the pulley in gear, and with a working pressure exactly in proportion to the electro-motive force of the current passed through the magnet *F*, and which can be regulated at the will of the operator. It remains in this condition until released by

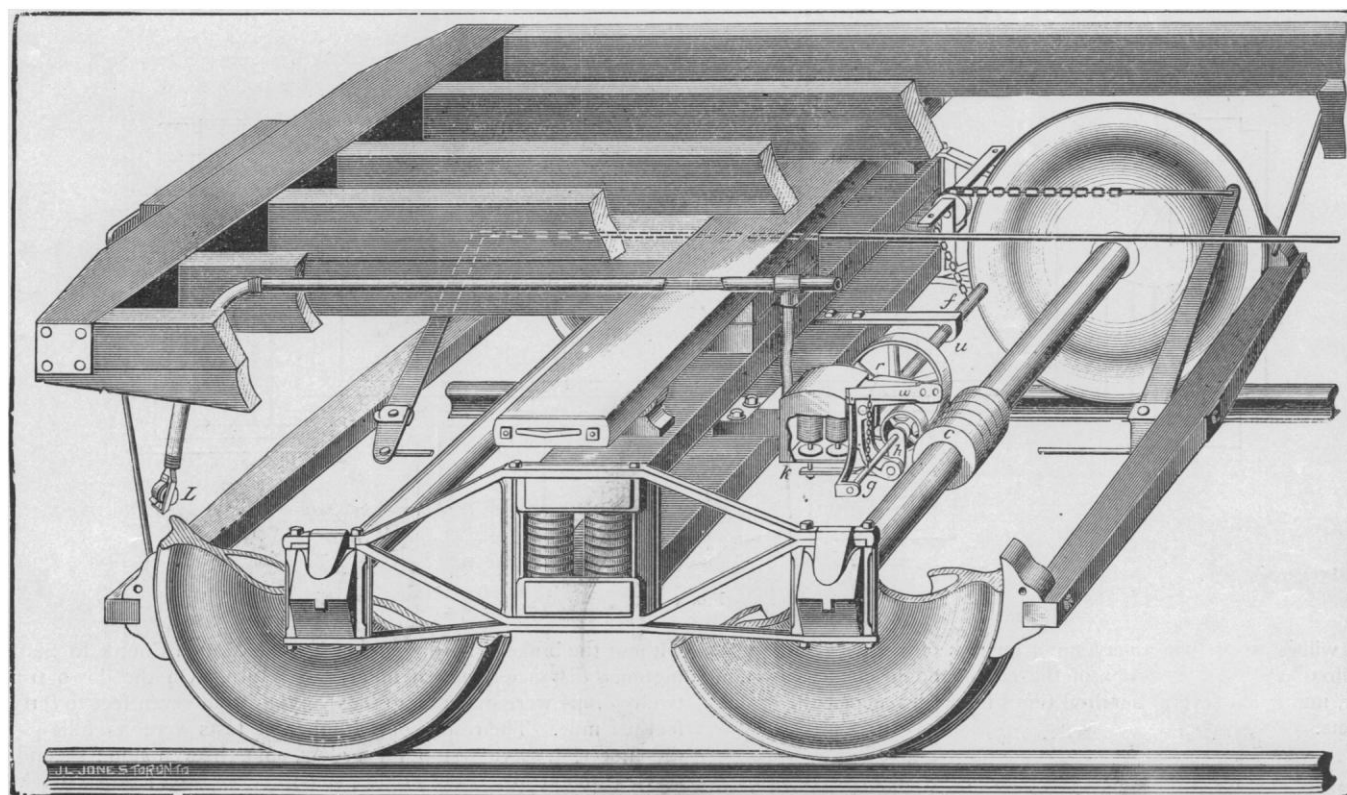


FIG. 1.—THE WIDDIFIELD AND BOWMAN ELECTRIC BRAKE.

difficulty by the use of electricity, which gives simultaneous application or release of the brakes on the longest train.

Referring to the accompanying illustrations, Fig. 1 shows the application of the brake to the truck of the car, and Fig. 2 shows the details of the operating mechanism attached to the different cars; Fig. 3 shows the arrangement of the circuits, switches, and batteries; and Fig. 4, the coupling between the different cars.

A friction-pulley, *c*, about six inches in diameter, composed of fibre and soft metal, is cast on one of the car-axes. To apply the brakes, a momentary current of electricity is passed through conductors *B* and *C* (Fig. 3), causing electro-magnet *F* (Fig. 2), through its connection with spring-lever *h*, to bring the pulley *e* in

the operator by closing the circuit through conductors *B* and *D*, and magnet *p*, the armature-core of which, *n n*, is thus drawn upward, and trips the ratchet-pawl, and thus releases the brake.

The electrical energy is supplied by a storage-battery of about 10 cells, located on the locomotive; and it is estimated that a battery having a capacity of 100 ampère hours will, in ordinary freight-train service, require charging only about once in six months. In addition to the battery on the engine, an auxiliary battery is placed on the rear car, in order that, when circumstances require it, the brakes can be controlled from the rear of the train.¹

¹ The brake and release magnets being in multiple arc, the power per car is the same, whether the train consist of one car or any number of cars.

Both brake and release circuits are normally open ; but magnets Q and Q' are in closed circuits with one or two cells, and so located that if the circuit TB should be broken by the train accidentally separating, the armatures P'' and P''' instantly fall, and automatically close the circuits on the conductors C and B , thus applying the brake to both sections of the train automatically.

The engine plant is light and portable, and can at any time be transferred from one locomotive to another by two men in a few minutes' time.

On May 21 a trial of this brake took place on the Lehigh Valley Railway. The train consisted of fourteen empty box-cars equipped with the brake, engine, tender, caboose, and one passenger-car

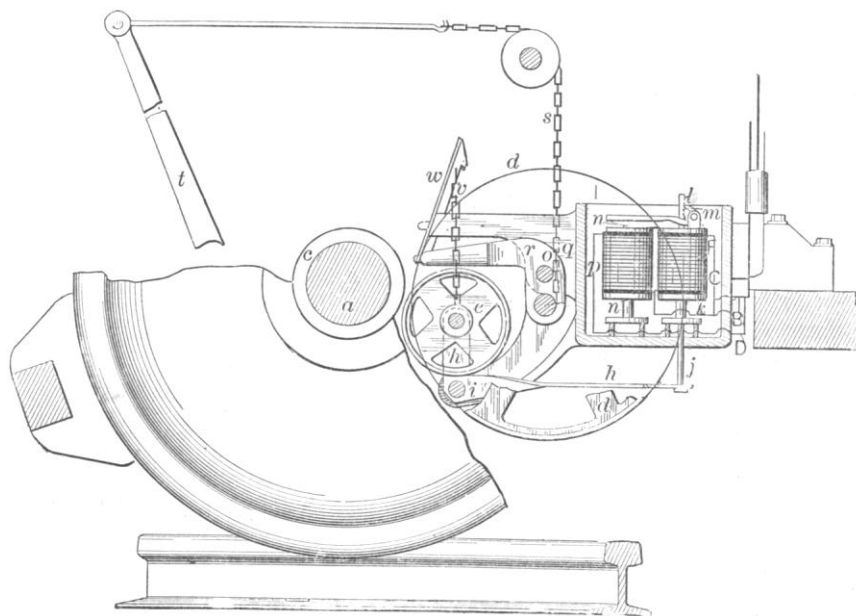


FIG. 2.

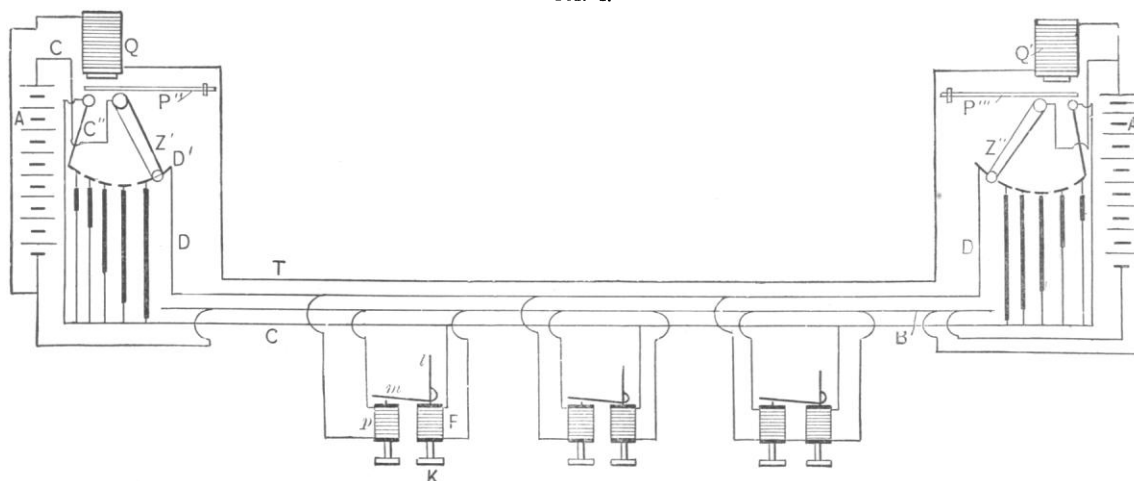


FIG. 3.

It will be seen that a very small amount of electrical energy is required, by the introduction of the compound levers and friction gear, multiplied several hundred times before it reaches the brake-beams.

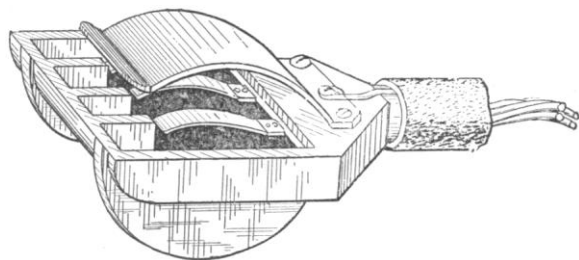


FIG. 4.

The inventors claim that this brake will perform all the functions of the air-brakes, and has the very important advantages that the train-men never lose control of it, as is the case with the air-brake, when a train is accidentally separated, and also that it will stop the longest train with no shock whatever.

without the brake. A run was made from Mauch Chunk to Slatington, a distance of eleven miles, and return. On the down trip twelve stops were made on grades varying from seven feet to forty feet per mile. The results of a number of tests were as follows : the first test, service stop for orders, smooth even stop ; second, service stop at Mr. Lentz's office, smooth even stop ; third, break-away, brakes applied automatically (speed, 25 miles), stopped in 17 seconds ; fourth, brakes applied from the top of the car (speed 25 miles), stopped in 20 seconds ; fifth, emergency stop (speed 35 miles), in 17 seconds ; sixth, emergency stop, 6 cars in front only, braked (speed, 20 miles), in 25 seconds ; seventh, long-service stop (speed, 30 miles), in 11 seconds ; eighth, slow-up to 5 miles an hour, and go ahead ; ninth, short-service stop (speed, 25 miles), in 38 seconds ; tenth, emergency stop (speed, 30 miles), in 20 seconds ; eleventh, fly cars into siding ; twelfth, emergency stop (speed, 35 miles), in 22 seconds.

The eighth, "slow-up," was a good even partial stop, with quick release of brakes, when ordered to go ahead. The eleventh, "fly car on to siding," was particularly well done, and the control of the brake-power from the caboose was very favorably commented on. The return trip was made during a shower. Several emer-

gency and service stops were made to test the brakes on a slippery rail, all of which were made with great success. The extreme smoothness of the stops, absence of shocks to rear car, the perfect control of the brakes both from the engine and caboose, were noticeable features in this test.

less than one minute per day. This is on a road about $1\frac{1}{2}$ miles long, having $3\frac{1}{2}$ -per-cent grades, operating trains at from 4-minute to $1\frac{1}{2}$ -minute intervals (since reduced to $1\frac{1}{2}$ minutes), with a speed of 10 miles per hour. It may be doubted if any road in this or any other country can show a better record. The grips

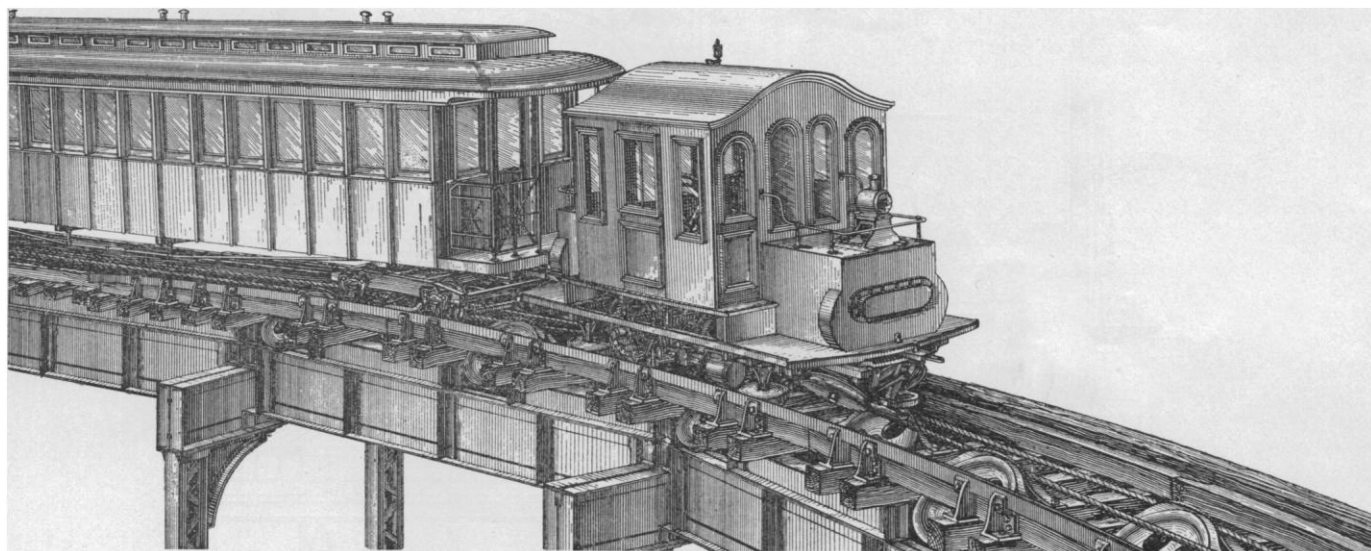


FIG. 1.—RAPID TRANSIT CABLE COMPANY'S GRIP MOTOR.

CABLE RAILWAYS.

CABLE railways have, where properly constructed, given great satisfaction, and the system has steadily grown in favor since its introduction on Clay Street, San Francisco, Cal., in 1873. The best example of a line of this character for heavy service is to be

there used consist of two pairs of packed wheels or rollers, set in frames opposite each other. Between these is a pair of solid gripping-jaws. The cable is first brought into contact with the rollers, after which the jaws come into action, and serve as a lock. This grip has these great disadvantages, however: inability to take hold

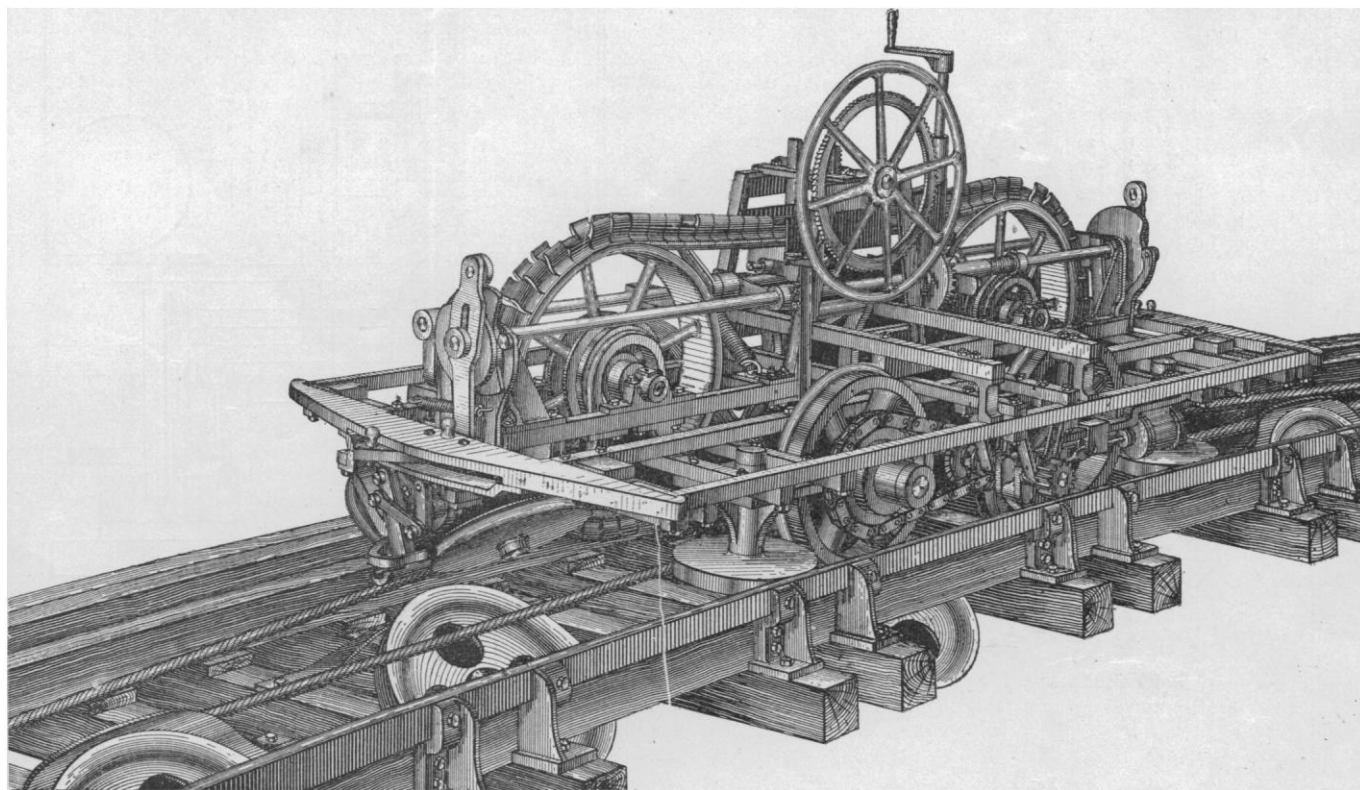


FIG. 2.—MOTOR WITH CAB REMOVED.

found on the New York and Brooklyn Bridge, over which passengers were first taken Sept. 24, 1883, from which time to May 1, 1888, 91,376,778 passengers were carried; and the delays to traffic due to the cable system amounted in the aggregate to but 20 hours and 46 minutes, — an average per month of only $23\frac{1}{2}$ minutes, or

of the cable except at certain fixed points, or to operate on curved tracks; and too small contact of the rollers with the cable; and, to exert the requisite gripping-power on the cable, it must be applied with great force, especially at the time of starting the train, when the greatest power is required. This "pinch" on the cable

is destructive to the strands, and the solid jaws are brought into action too quickly; yet the first cable was in continuous use from the opening of the railway to Nov. 7, 1886, and the second was

3. Can a sufficiently powerful grip be devised to haul the heavy trains in use on elevated railways, provided the ability to grasp the cable is demonstrated?

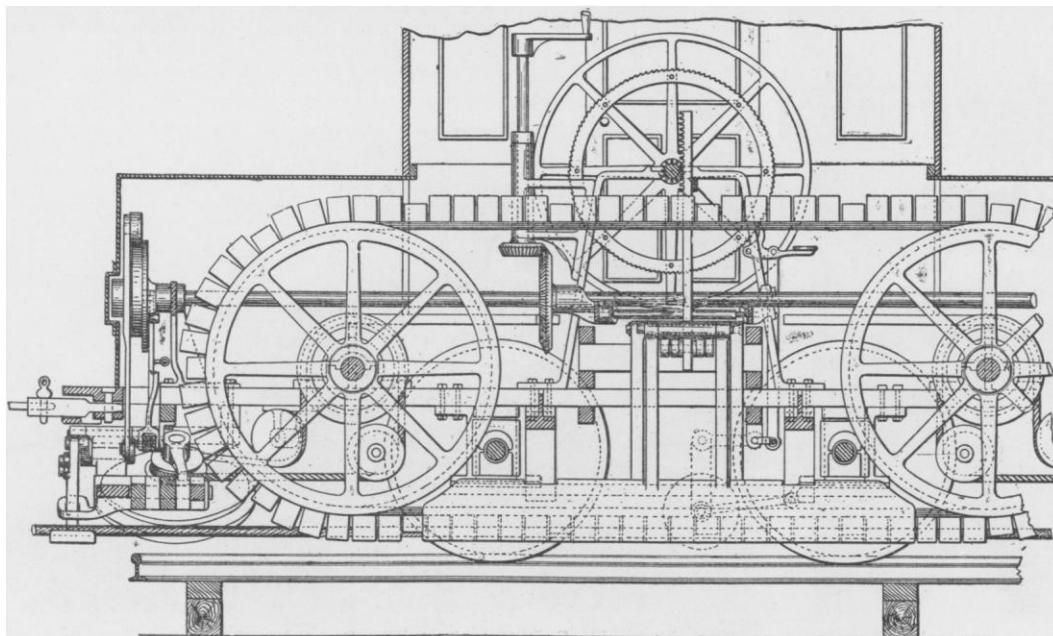


FIG. 3.

still serviceable in April, 1888, while the roller-packing gives a service of 20,000 miles.

But grips on each car, and ten miles per hour, regardless of its inapplicability to curved lines or inability to take hold of the cable, would not answer for elevated railways; and a cable moving at a

4. Will any saving be effected in operating expenses by substituting cable and stationary engines for the system now in use?

To each and all of these questions the Rapid Transit Cable Com-

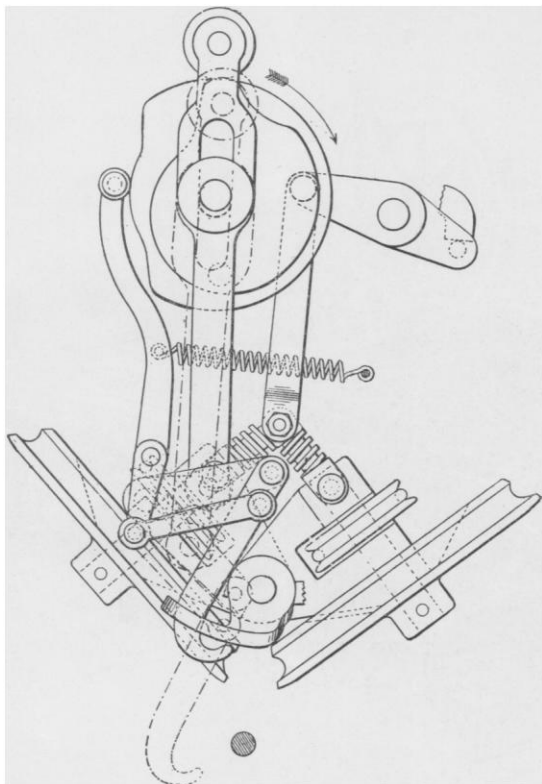


FIG. 4.

greater speed would, if brought into contact with such rollers, very soon destroy the packing.

1. Is it, then, possible to run a cable at sufficient speed to provide rapid transit?

2. Is it possible, provided the required speed can with safety be obtained, to grasp the cable with any effective gripping-device without great destruction to either cable or grip, or both?

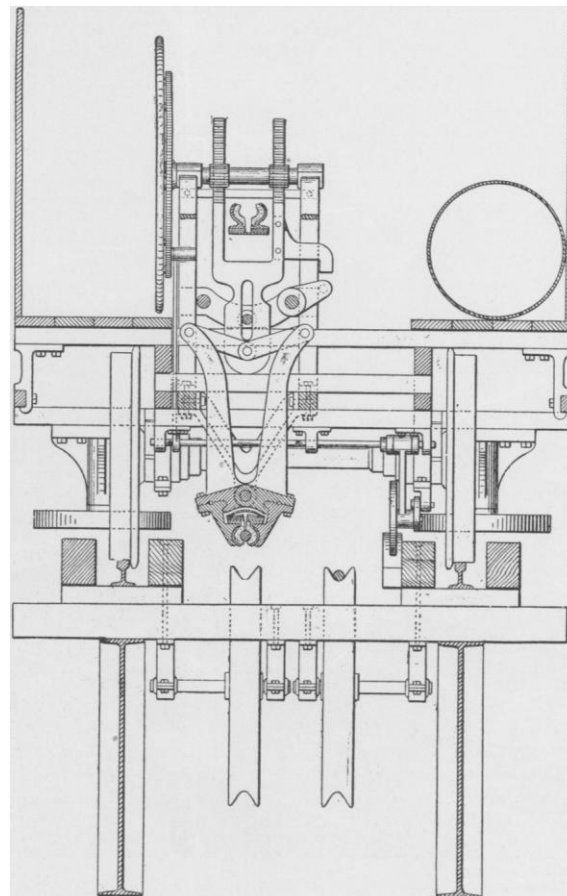


FIG. 5.

pany of New York reply in the affirmative, and endeavor to prove their position as follows:—

1. The present elevated railways in New York are operated at an average speed, including stops, of 12.18 miles per hour, or 17.86

feet per second; express-trains, 18.23 miles per hour, or 26.74 feet per second. Allowing for station stops, the maximum speed will be under 20.5 miles per hour, or 29.9 feet per second.

The speed at which a cable for the transmission of power can be run may be determined by the liability of the pulleys to burst under

brakes are brought into action, and the pulling-power of the cable gradually overcomes the inertia of the train.

3. In answer to the third question it is sufficient to state that the length of the gripping-surface is 60 inches, which, used with a cable of $1\frac{3}{4}$ inches diameter, and assuming only three-fourths of

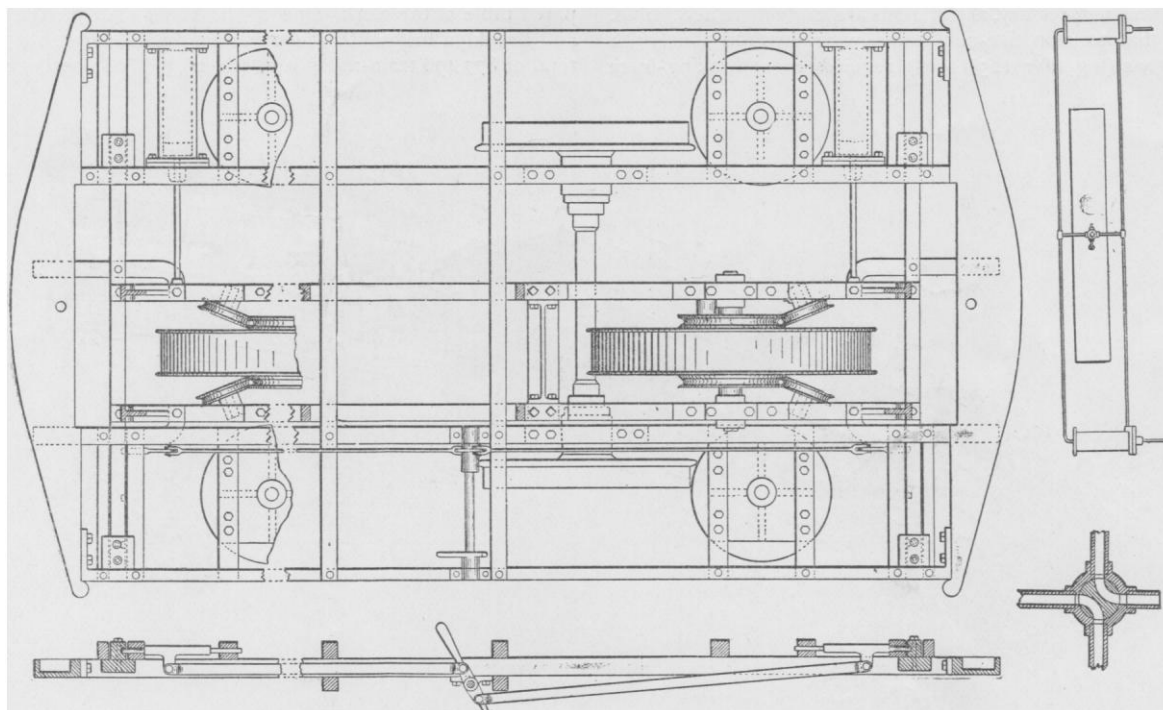


FIG. 6.

the action of centrifugal force, and this safe speed is determined by Professor Unwin, for cast iron of 4,500 pounds per square inch tensile strength, to be 215 feet per second; so that, if we adopt 25 miles per hour as the desired velocity, which is nearly one-fourth greater than now used, we shall have for our working speed 36.66 feet per second, or about one-sixth of the safe limit for cast-iron pulleys. Hence there can be no question as to speed.

2. To one familiar only with the cable grips at present in use, it is but natural that this second question should cause considerable apprehension, for there is not one which could be successfully used for such velocity as has been above assumed. But the Rapid Transit Cable Company have had this question of providing a gripping-apparatus applicable for heavy trains and high velocity constantly in view, and their experiments and labors have been largely devoted to overcoming the difficulties encountered; in fact, it may be said to have been a *sine qua non*, and they are at last prepared to claim a successful solution of the problem. Their grip for such service as is now under consideration is placed on a separate truck or car, and hauls the train as a locomotive; but instead of weighing $23\frac{1}{2}$ tons, concentrated as largely as possible on four driving-wheels, it weighs less than 10 tons; it is supplied with pumping-cylinders to provide compressed air or vacuum for operating train-brakes, and for moving itself about yards or switching from one track to another. Curves of any radii which are practicable for any other motive power are passed with equal facility, and the cable can be picked up at any and all points on the line. It is arranged for duplicate cables, as is also the driving-machinery, so that in case of any accident the idle cable may be picked up without a delay exceeding five minutes, wherever the trains may be. The gripping-device gives a very long contact, thus reducing the unit pressure on the cable for a given weight of train. The gripping surface is of leather; and, to still further protect the parts in contact from excessive wear, a very simple device sets the movable gripping-parts into motion automatically before they are brought into contact with the moving cable. Thus that which in all other grips would be speedily cut out by the cable is in this case preserved, and little or no cutting can take place. When the parts are moving at the cable speed, the pressure is applied, the grip-

the periphery to be subjected to the gripping-pressure, will give an available area of 246 square inches. The friction of leather on a cable may safely be taken as 0.6 of the pressure applied, so that for every pound of pressure there is 0.6 of a pound of pulling-power. An elevated-railway locomotive with 37,400 pounds on

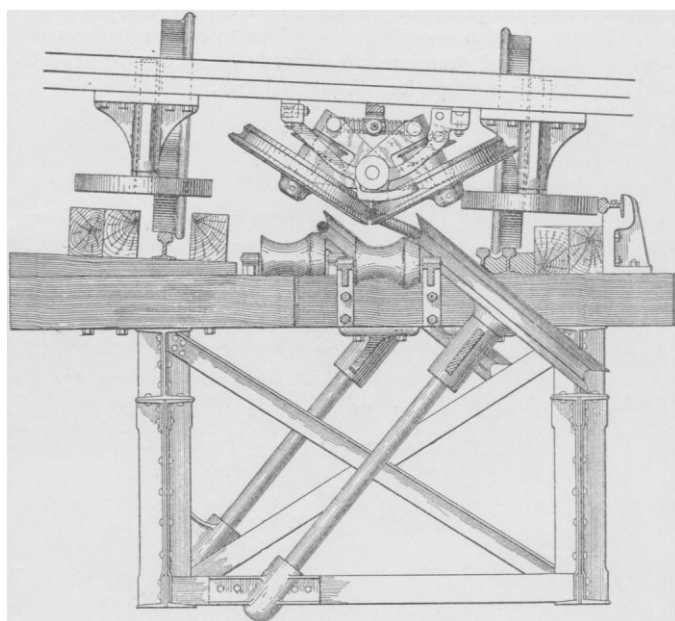


FIG. 7.

drivers, may, under the most favorable conditions, exert from one-third to one-fourth of this weight as tractive force, an average of 11,400 pounds, which this grip will produce with less than 78 pounds per square inch, which may be multiplied several times without injury to cable or grip.

4. Next as to the question of economy. In a cable system,

water and coaling stations are unnecessary; less water is needed, less oil and waste, and from one-half to one-third the quantity of coal, which may be of an inferior quality, costing perhaps one-half of what is now paid. Grades cease to be obstacles, and expensive constructions like that in New York at 110th Street and Eighth Avenue become unnecessary, and stations are made more accessible. It is clear that to stop five-car trains weighing 100 tons, with engine $23\frac{1}{2}$ tons (together $123\frac{1}{2}$ tons), requires more braking-force

trains of the Manhattan Elevated Railway of New York City travelled a total of 7,202,966 miles during the year ending Sept. 30, 1887, carrying 158,783,241 passengers. The expense of operating the road for the same period was \$4,508,467, being 61.89 cents per train-mile run, or 2.79 cents for each passenger. A carefully prepared table of the work done by the cable-road on the New York and Brooklyn bridge for the year ending May 31, 1887, shows a total of 877,496 train-miles run, and 26,388,808 passengers carried.

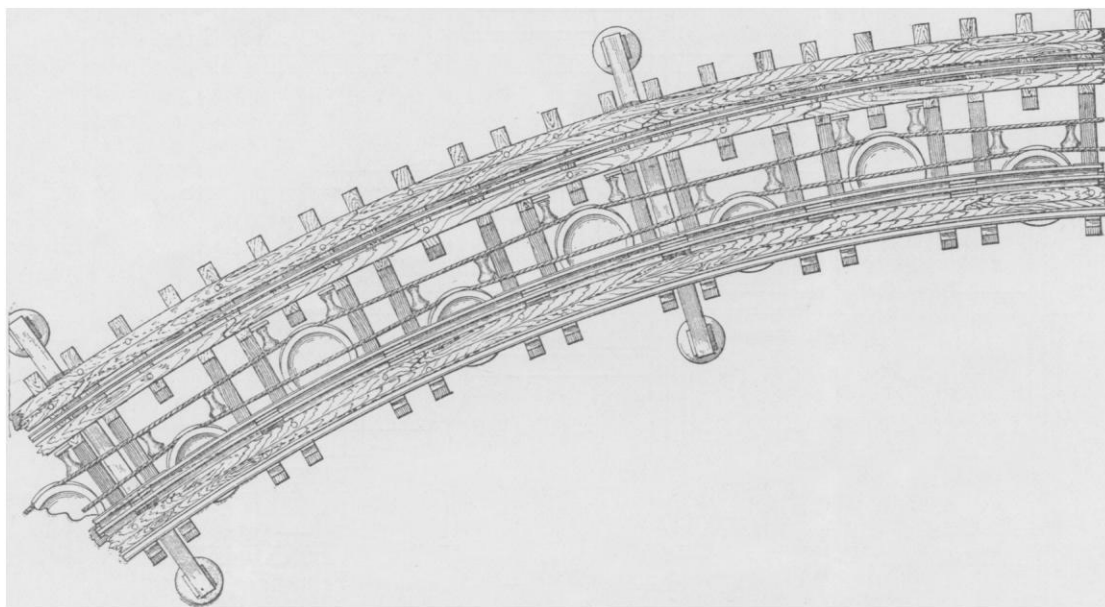


FIG. 8.

than the same train of cable-cars with a 10-ton motor, a total of 110 tons; it is also evident that the lighter train will attain full speed more quickly. The horse-power of a locomotive is least at starting, just at the time when the greatest effort is needed; whereas with the cable-train the motive power (the cable) is already in full speed, with the power of the enormous driving-engines ahead of it. It is a question in cable-traction how to come into full speed slowly enough; and therefore, to be entirely successful, a cable-road requires the most perfect differential grip.

The operating expenses were \$402,894, being 45.84 cents per train-mile, or 1.52 cents per passenger. In this particular instance it would appear that the cost of carrying each passenger on the cable-road was less than half that on the steam-road, while the cost per train-mile run was at least one-fifth less on the former than on the latter.

In Fig. 1 the Rapid Transit Cable Company's motor is seen perspective, coupled to a train; and in Fig. 2 it is represented with the cab removed.

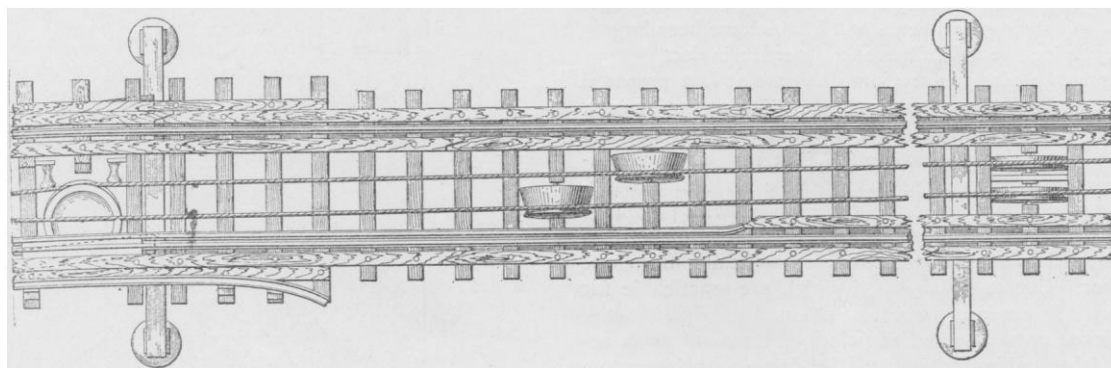


FIG. 9.

As to the amount of power expended in driving the plant, reference is made to Mr. Leverich's paper on the New York and Brooklyn Bridge, wherein it is stated that the highest horse-power developed by the engines was 394.5, and that to drive the plant alone, cable included, required 47.7 horse-power, which gives 87.99 per cent to be utilized for cars and passengers.

A comparison of the motive-power expenses of cable and locomotive roads may be made from recent reports. According to the report of the railroad commissioners of the State of New York, the

Fig. 3 is a partial longitudinal section on a broken plane, in which is shown the revolving belt of clips, with inner surfaces of leather, between which the travelling cable is held; and the large capstan-wheel for applying and releasing the gripping-jaws, through which the belted clips run (as shown in dotted lines), and are forced with greater or less pressure against the cable, thus retarding the belt proportionately from the consequent friction of the outer metallic plates of the clips in contact with the metallic guide and gripping-jaws. This produces a greater or less differential

speed of the revolving belt and travelling cable to the speed of the motor, and thus enables a gradual start or variable train-speed without injury to the grip or cable. To the left of the capstan-wheel is a vertical shaft having on top a crank with handle or a wheel, and terminating below in a bevel-gear wheel which engages with another keyed to the long shaft, by means of which the pick-up is operated, as well as the carrying-sheaves at the end of the motor, which serve to properly guide the cable in its relationship to the revolving belt, and cause it to revolve at the same speed as the travelling cable, before their contact. These are all very simply and positively accomplished by the continuous turning of the one crank, which, being a uniform motion, precludes any confusion of the operator.

Fig. 4 shows the pick-up and supporting wheels in detail, and their transposition when operated. Though the pick-up is capable of being worked at any time, its use is seldom required, as the cable travels through the supporting wheels almost continuously, — during stops at stations and when varying the speed, — and is seldom dropped but at crossings, ends of sections, and the termini. In dotted lines below the capstan-wheel is the automatic tripping-device to release the cable at the end of a section or at any fixed point.

Fig. 5 is a cross-section showing the shape of the clip-belt in its position between the gripping and braking jaws, which get their force from the connected compound levers and toggle, actuated by the large capstan-wheel. This grip is seen holding the right-hand cable, but may be easily shifted on its movable supporting-frame, pneumatically with cylinders, as shown in plan view in Fig. 6 (or with a capstan-bar), by the engineer or grip-man, to the centre (as required with a single cable), or to accommodate the left-hand cable (as in this duplicate system); which cable is seen supported by the end guide-wheels (previously referred to in connection with Figs. 3 and 4) in Fig. 7 in their relationship with the guard-wheels to the guard-rail and curve-carrying sheaves, Figs. 8 and 9 respectively showing the same duplicate cables in plan of track on curve, and its approach. This motor is also provided with combined air-pumps and engine-cylinders, and reservoirs.

Being adapted to a duplicate cable system that provides against the delays which might possibly occur in the use of a single cable, the grip is shifted to a position directly over the cable it is desired to take (see Fig. 6), two methods being provided in case of accident to one or the other. The horizontal crank or wheel actuating the vertical shaft (see Fig. 3) is then revolved continuously in the same direction. This causes the pick-up at each end of the motor (see Figs. 3 and 4) to descend, pass under the cable, lift it, and throw in the carrying-wheels (see Figs. 3 and 4) to support the cable in an elevated position, to be gripped by the clip-belt after the same has been put into motion by contact of the same supporting-wheels with the travelling cable; following which the pick-up is lowered slightly, and withdrawn to one side of the cable. The train can now be started and speeded with a graduation exactly as the operator may intend by the turning of the large capstan-wheel that governs the powerful mechanical combination (see Fig. 4) which actuates the braking and gripping-jaws, increasing or lessening the required tractive power, and correspondingly regulating the speed of the train without any undue exertion of the operator.

If for any reason it should be necessary to communicate with or signal to the power-house, or stop one cable and start the other, it may be done direct from the trains or motors, at any point on the line of railway, by a patent electric device; and, in the event of thus transferring the power from one to the other of the duplicate cables, the grips are shifted conformably (see Fig. 6).

THE WORK OF THE PEABODY MUSEUM OF AMERICAN ARCHÆOLOGY AND ETHNOLOGY.

THE twenty-second annual report of Professor F. W. Putnam shows that the work of the Peabody Museum of American Archæology and Ethnology is constantly growing in importance. From the interesting contents of his report we glean the following facts.

The museum purchased for a moderate sum, from the Rev. Samuel Lockwood of Freehold, N.J., a collection of particular importance in supplementing the Abbott collection from the vicinity

of Trenton. Over thirty years ago Mr. Lockwood investigated the great shell-heap at Keyport, and was the first to call attention to its character. This shell-heap, with many of the objects from it, was afterwards described by Dr. Rau, and has become historical in American archæology. From this large refuse-pile the most important part of the Lockwood collection was obtained. In addition, there are many stone implements from various places in Monmouth, Middlesex, Mercer, and Ocean Counties. Among them are several paleolithic implements, and a large number of argillite points, found under peculiar conditions, and showing a degree of weathering which is conclusive evidence of their extreme antiquity. As the shell-heap at Keyport, once covering a mile or more in length along a narrow strip, bordered upon one side by the ocean and on the other by Raritan Bay, is entirely obliterated, it is of importance that the materials obtained from it be now in the museum for comparison with the very extensive collections from the shell-heaps of New England. The fact that at certain places on this narrow strip between the bay and the sea the prevailing implements were of argillite and of great antiquity has a peculiar significance in connection with those from Trenton, and again points to an intermediate period between the paleolithic and the late Indian occupation of New Jersey. The collection also contains three Indian crania from Monmouth County, and a few objects from various places beyond the immediate region of Keyport. Mr. Lockwood has a considerable number of field notes, made during his long-continued explorations of the vicinity of Keyport, and it is his intention to prepare a full account of his observations and of the collection, for publication by the museum.

In the list of officers given in connection with the last report, it will be noticed that the name of Mr. Hilborne T. Cresson of Philadelphia is given as a special assistant in the field. Mr. Cresson, while studying abroad, became interested in the archæology of France and Switzerland, and while at home has devoted his leisure time to a study of American archæology, upon which he has published several important papers. About 1870 his attention was called to the existence of stakes or piles, observed by a fisherman, in the mud at the mouth of Naaman's Creek, a small tributary of the Delaware River. Circumstances at the time did not permit of more than a hasty examination and the taking of a photograph of the locality. It was not until Mr. Cresson's return from France, in 1880, that means were furnished, by a gentleman of Philadelphia, to prosecute the work. His examinations soon led to the discovery of three distinct localities, near to each other, which he designated Stations A, B, and C, and around which were found a very important and instructive collection of stone implements, a few points and fragments of bone, and a human tooth. At one station a number of fragments of rude pottery were found, and at this were obtained the several pile-ends now in the museum. This collection he has generously given to the museum, and proposes soon to prepare a full account of his discoveries for publication. The museum is also much indebted to Mr. A. B. Huey of Philadelphia for a number of specimens which he obtained while with Mr. Cresson during the examination of Station B, and to Mr. W. R. Thompson of Philadelphia, for several potsherds, and a large stone maul with a hole drilled through it, from the same station.

When it is recalled that this is the first indication in North America of any thing even remotely resembling the crannoge-like structures of the European bogs, the importance of Mr. Cresson's labors will be appreciated; and the museum is fortunate in having his co-operation in its work, — a co-operation which he states he freely gives from his appreciation of the objects and methods of the museum. The specimens are now exhibited in the museum, and are of great importance in the study of the periods of occupation of the Atlantic coast. The discovery by Mr. Cresson of the fact that at only one station pottery occurs, and also that at this station the stone implements are largely of jasper and quartz, with few of argillite, while at the two other stations many rude stone implements are associated with chipped points of argillite, with few of jasper and other flint-like material, is of great interest in connection with the specimens collected by Dr. Abbott and Mr. Lockwood in New Jersey, to which allusion has been made.

In connection with his studies of the river-stations, Mr. Cresson has examined the peat marshes and land along the shore of the

Delaware, and has obtained stone implements from various points, both personally and by interesting friends and residents in the work he was engaged upon. He has also made a collection to show the character and relation of the peat to the river-deposits, and in various ways has made a thorough study of the connection of the river-stations with the early inhabitants of the shore.

Mr. Cresson's investigations have also been carried on in relation to the paleolithic implements found in the gravel, and he has been so fortunate as to discover two specimens *in situ* in the older gravel near Claymont, Newcastle County, Del. He also, in company with Mr. Thompson, made a visit to Indiana, and examined the gravel on White River above Medora in Jackson County. Here he was so fortunate as to find a large paleolithic implement of gray flint, in place in the gravel of the bluff of the east fork of White River. A rudely chipped implement, probably of later date, was also found in the gravel about a mile distant from the first, and was presented to the museum by Mr. Thompson.

Mr. Cresson has prepared a full account, which will soon be printed, of the discovery of these implements. In the mean while it is only necessary to call attention to the importance of these discoveries in relation to the distribution of paleolithic man in America. The value of the material for this purpose cannot be over-estimated, containing as it does nearly all the implements known from the New Jersey gravels, in the Abbott and Lockwood collections, the two specimens from Delaware and one from Indiana in the Cresson collection, the two from Ohio found by Dr. Metz, and the Babbitt collection from Minnesota. For comparison with these, the museum has numerous specimens from the gravels of France and England.

Professor Putnam's remarks on the results of his researches on the Serpent Mound will be read with interest. He says, —

"We have discovered many facts pointing conclusively to considerable antiquity in the occupation of the region about the Serpent Mound. We know historically that a hundred years ago the region was inhabited by Indians, and we have found graves that probably belong to that time, or immediately preceding it, and we have also found another class of burials having every indication of far greater antiquity. Here upon the Serpent Mound Park, the property of the museum, and not far from the Serpent, are three burial-mounds with two entirely different methods of burial. Here are a village site and a burial-place occupying the same area. A recent and an early period are everywhere evident as the exploration goes on. Every thing relating to the construction of the great earthwork points to antiquity. The signs of the later occupation of the region about it have nothing remarkable: simple ash-beds where the dwellings stood; burials in the black soil, with or without protecting stones about the graves; no elaborate structures or indications of special ceremonies in connection with the burial of the dead; intrusive burials in a conical burial-mound; — every thing, on the one hand, pointing to a recent and not long-continued abode upon the spot; on the other hand, antiquity and special ceremonies; — a conical mound of considerable size, erected as a monument over the body of a single person, buried after some great ceremony in connection with fire; another mound under which were four graves (one deep down in the clay under many large stones; three others over this, with large stones about the graves and over them, and a mound of earth over all); in another instance a grave deep in the clay, with flat stones at the bottom, upon which the body was placed, and over the body many large stones, covered by the black soil of recent formation; and in this black soil, over the stones, a grave of the later period; in another place, under the black and recent soil, stones irregularly placed upon the clay, marking graves, or places where fires were made; two and three feet under these once surface-piles of stones, the graves, with skeletons so far decayed that only fragments could be secured (in several instances only the outlines of the bones could be traced in the clay; in some cases the bones in part were preserved by the infiltration of iron, and the crevices in the clay about the bones were filled with limonite, — all showing great antiquity in contrast to the more recent burials). These older burials were made in connection with ceremonies during which fire played an important part, as shown by the burial of ashes and burnt materials with the bodies, and also by the stone fireplaces near the graves.

In several of these ancient graves, objects were found similar to those which we have obtained in the ancient mounds of other parts of the State. In the recent graves, with the skeletons just under the recent black soil, only now and then an arrow-point of flint or a stone celt was found, with fragments of rude pottery, such as are distributed over the surface of the village site. In the ancient graves not a fragment of pottery was found. In one of the oldest graves containing two skeletons were nearly fifty stone implements and several ornaments, among them one cut out of a crystal of galena.

"Of the two periods, our explorations have shown that it can hardly be questioned but that the Serpent Mound was built by the people of the first, that it was connected with their beliefs and their ceremonies, and that in its sacred precincts some of their dead were buried.

"This seems to be the legitimate conclusion reached by our work to this time. I shall still have time for further explorations before leaving this interesting spot, and there is much to be done in the immediate vicinity another year."

NOTES ON THE USE OF GRATINGS.¹

THE ghosts are very weak in most of my gratings. They are scarcely visible in the lower orders of spectra, but increase in intensity, as compared with the principal line, as the square of the order of the spectrum: hence, to avoid them, obtain magnification by increasing the focal distances instead of going to the higher orders. The distances from the principal line in my gratings are the same as the distances of the spectra from the image of the slit when using a grating of 20 lines to the inch. They are always symmetrical on the two sides, and about $\frac{1}{12}$ of an inch for the violet and $\frac{1}{8}$ of an inch for the red in a grating of 21 feet 6 inches radius in all orders of spectra. When the given line has the proper exposure on the photographic plate, the ghosts will not show, but over-exposure brings them out faintly in the third spectrum of a 20,000 grating or the sixth of a 10,000 one. They never cause any trouble, as they are easily recognized and never appear in the solar spectrum. In some cases the higher orders of ghosts are quite as apparent as those of the first order.

The gratings with 10,000 lines to the inch often have better definition than those of 20,000, as they take half the time to rule, and they are quite as good for eye-observation. They can also be used for photographing the spectrum by absorbing the overlying spectra, but there are very few materials which let through the ultra-violet and absorb the longer wave-lengths. The 10,000 gratings have the advantage, however, in the measurement of wave-lengths by the overlapping spectra, although this method is unnecessary since the completion of my map of the spectrum. By far the best is to use a 20,000 grating, and observe down to the D line by photography, using erythrosin plates from the F line down to D. Below D, cyanine plates can be used, although the time of exposure is from ten to sixty minutes with a narrow slit. The solar spectrum extends to wave-length 3,000, and the map has been continued to this point. Beyond this, the coincidence with the solar spectrum cannot be used, but those of the first and second or second and third spectra can be.

Some complaints have been made to me that one of my gratings has no spectrum beyond 3,400, even of the electric arc. I have never found this the case, as the one I use gives wave-length 2,200 readily with thirty minutes' exposure on slow plates, requiring five minutes for the most sensitive part, and using the electric arc. With sensitive plates, the time can be diminished to one-fifth of this.

For eye-observations, a very low power eye-piece of one or two inches focus is best. This, with a focus of 21 feet 6 inches, is equivalent to a plane grating with a telescope of a power of 100 or 200.

In measuring the spectra, an ordinary dividing-engine, with errors not greater than $\frac{1}{1000}$ of an inch, can be used, going over the measurements twice with the plate reversed between the separate series. The plates are on so very large a scale, that the microscope must have a very low power. The one I use has a 1-inch

¹ From Johns Hopkins University Circulars, May, 1889.

objective and a 2-inch eye-piece. The measured part of the plate is about a foot long, the plates being 19 inches long.

All the spectrum photographs taken at different times coincide perfectly, and this can be used for such problems as the determination of the atmospheric lines. For this purpose, negatives at high and low sun are compared by scraping the emulsion off from half the plates, and clamping them together with the edges of the spectra in coincidence. The two spectra coincide exactly line for line except where the atmospheric lines occur.

This method is specially valuable for picking out impurities in metallic spectra, using some standard impurity in all the substances to give a set of fiducial lines; or, better, obtaining the coincidence of all the metals with some one metal, such as iron. Making the iron spectrum coincide on the two plates, the other spectra can be compared. This is specially possible, because the focus of a properly set up concave grating need not be altered in years of use; for, when necessary, it can be adjusted at the slit, keeping the distance of the grating from the slit constant.

The spectrum of the carbon poles is generally too complicated for use with any thing except the more pronounced lines of metals, there being, at a rough guess, 10,000 lines in its spectrum. However, in photographing metallic spectra, but few of these show on the plate, as they are mostly faint. The spark-discharge gives very nebulous lines for the metals.

Most gratings are ruled bright in the higher orders; but this is more or less difficult, as most diamond-points give the first spectrum the brightest. Indeed, it is very easy to obtain ruling which is immensely bright in the first spectrum. Such gratings might be used for gaseous spectra. Short-focus gratings of five feet radius of curvature, very bright in the first order, require only a fraction of a second exposure for the solar spectrum, and the spectrum of a gas can be obtained in less than an hour. H. A. ROWLAND.

NOTES AND NEWS.

A SCHOOL for boys will open Wednesday, July 3, 1889, at North Edgcomb, Me., and will continue through the long vacation. Its primary object will be to fit boys for the college-admission examinations in the fall; but others who desire to advance in their studies, or to make up deficiencies during the summer, will there find an excellent opportunity. Especial attention will be paid to those who have been conditioned in the spring examinations. The staff of instructors will consist of four Harvard graduates, who are specialists in their several departments, and experienced tutors. The location affords good facilities for tennis and base-ball, as well as for boating, bathing, and fishing. As an experienced man will have special charge of the out-of-door sports of the students, a few boys will be received who do not wish to study, but who desire to pass the summer, or a portion of it, in a pleasant and healthful locality which combines country and seashore advantages. For further particulars, address Louis L. Hooper, Harvard University, Cambridge, Mass.

— It has been announced that in the event of the final loss of the McGraw-Fiske suit, involving \$1,500,000, bequeathed to the library of Cornell, Mr. Henry W. Sage of Ithaca would pay for the library building, to cost over \$200,000, on which work has begun. But it has not been made public till now, that, in addition to standing the cost of the building, Mr. Sage offers, if the suit is lost, to give the library an endowment of \$300,000. If the McGraw-Fiske suit is won, as is confidently expected, Mr. Sage's half a million will probably come to the university for other purposes. The giving of this sum will make Mr. Sage's benefactions to the university amount to about \$1,000,000 in cash, besides counsel and services.

— In the *American Journal of Science* for March, 1887, and the *London, Dublin, and Edinburgh Philosophical Magazine* for the same month, Mr. Henry A. Rowland has published a list of standard wave-lengths, as far as could be observed with the eye, with a few imperfectly observed by photography, the whole being reduced to Bell's and Pierce's values for absolute wave-lengths. Mr. Bell has continued his measurements, and found a slightly greater value for the absolute wave-length of the D line, and Mr. Rowland has reduced his standards to the new values. Nearly the whole

list has been gone over again, especially at the ends around the A line and in the ultra-violet. The wave-lengths of the ultra-violet were obtained by photographing the coincidence with the lower wave-lengths, — a method which gives them nearly equal weight with those of the visible spectrum. The full set of observations will be published hereafter, but the present series of standards can be relied on for relative wave-lengths to .02 division of Angström in most cases, though it is possible some of them may be out more than this amount, especially in the extreme red. As to the absolute wave-length, no further change will be necessary, provided spectroscopists can agree to use that of Rowland's table, as has been done by many of them. By the method of coincidences with the concave grating, the wave-lengths have been interwoven with each other throughout the whole table, so that no single figure could be changed without affecting many others in entirely different portions of the spectrum. The principal difference from the preliminary table is in the reduction to the new absolute wave-length, by which the wave-lengths are about 1 in 80,000 larger than the preliminary table. It is hoped this difference will not be felt by those who have used the old table, because measurements to less than .1 division of Angström are rare, the position of the lines of many metals being unknown to a whole division of Angström. As the new map of the spectrum has been made according to this new table, there seems to be no further reason for changing the table in the future. No attempt has been made to reduce the figures to a vacuum, as the index of refraction of air is imperfectly known; but this should be done where numerical relations of time period are desired. In the column giving the weight, the primary standards are marked S, and the other numbers give the number of separate determination of the wave-length, and thus, to some extent, the weight. Many of these standards are double lines, and some of them have faint components near them, which makes the accuracy of setting smaller. This is specially the case when this component is an atmospheric line whose intensity changes with the altitude of the sun. The principal doubles are marked with d; but the examination has not been completed yet, especially at the red end of the spectrum, and a table of the standard wave-lengths is given on p. 78 of the May number of the "Johns Hopkins University Circulars."

— Schneider & Co. of France have recently taken out a patent, as we learn from *The Engineering and Mining Journal*, for manufacturing steel containing a variable portion of copper, which is to be used in making artillery of large caliber, armor-plates, rifle-barrels, and projectiles. Ordinary copper is used for the purpose, care being taken to prevent it from oxidizing before it is mixed with the steel in the crucible; and the composition contains two to four per cent of copper, the alloy being capable of far more resisting power and more elastic and malleable than simple steel would be. This new material will also probably be valuable for making girders for building-purposes and ship-plates.

— Mr. J. S. Ames, in writing of the concave grating in theory and practice, says a word as to the difficulties of ruling gratings, which may explain why so many orders received at the Johns Hopkins University for gratings remain unfilled. It takes months to make a perfect screw for the ruling-engine, but a year may easily be spent in search of a suitable diamond-point. The patience and skill required can be imagined. For the past year, all attempts to find a point for the new ruling-engine have failed; and it is only within a few days that one has been found. Most points make more than one "furrow" at a time, thus giving a great deal of diffused light. Moreover, few diamond-points rule with equal ease and accuracy up hill and down. This defect of unequal ruling is especially noticeable in small gratings, which should not be used for accurate work. Again, a grating never gives symmetrical spectra, and often one or two particular spectra take all the light. This is of course desirable, if these bright spectra are the ones which are to be used. Generally it is not so. These individual peculiarities of gratings were fully treated by Professor Rowland in his lectures during the spring term of 1888, and have been embodied by him in a complete mathematical theory of the grating, which he has nearly ready for publication. It is not easy to tell when a good ruling-point is found; for a "scratchy" grating is

often a good one; and a bright ruling-point always gives a "scratchy" grating. When all goes well, it takes five days and nights to rule a six-inch grating having 20,000 lines to the inch. Comparatively no difficulty is found in ruling 14,000 lines to the inch. It is much harder to rule a glass grating than a metallic one; for to all of the above difficulties is added the one of the diamond-point continually breaking down. For this reason, Professor Rowland has ruled only three glass gratings, one of which has been lost, and the other two are kept in his own laboratory. These two were used by Dr. Bell in his determination of the absolute wave-length of the D lines.

— Among the interesting and successful recent inventions is a rolling-mill for producing sheet metal direct from the molten state, instead of rolling it from a billet or bar. A machine of this character has been at work for several months at the can-factory in Maywood, near Chicago. It is used for making sheet solder, six or eight inches wide, and $\frac{5}{16}$ of an inch thick, which it produces at the rate of 400 feet a minute. *The Engineering and Mining Journal* describes the apparatus as consisting of hollow rolls with cold water running through them. The water is introduced through the axles, and the rolls are of sufficient size to at once change the jet of melted metal into solid form as fast as it is fed. The powerful compression exerted by rolls upon the molten metal in forcing it between the two surfaces, and at the same time changing it to a solid body, tends to give to the sheet an even and highly finished surface. The inventors of the machine believe that the principle could be successfully applied to the rolling of Bessemer steel, as well as to softer metals. Mr. O. W. Potter, and other officers of the North Chicago Rolling Mill Company, recently examined the machine, and expressed themselves as being favorably impressed with its work.

— The *Railroad Gazette* calls attention to a double locomotive for the Indian State railways which is a novel departure from the common practice. The design is really a permanent double-header; that is, it is intended for use when the conditions are such as to require the use of two locomotives of the ordinary type, continually in tandem. This arrangement removes the necessity for two tenders, and renders easier the transmission of signals from one cab to another. There is nothing in this arrangement to criticise: it is really almost the only plan upon which locomotives of great capacity can be constructed with any approach to a minimum of weight per running foot of track. This general plan is not new in America, however. The well-known William Mason, of the Mason Locomotive Works of Taunton, Mass., constructed locomotives on this general plan many years since; and recently the South Side Rapid Transit Co. of Chicago, while investigating the possibilities of extending the usefulness of the proposed structure in years to come, decided that the adoption of a locomotive of a design similar to the one described above would enable them to haul nearly double the number of cars around the sharpest curves without increasing the load per running foot of the structure. *Engineering*, London, contains further description, together with an inset showing the locomotive quite completely.

— *Garden and Forest* states that in the garden of Professor Charles N. Shepard, Charleston, S.C., is a rose remarkable for its size and vigor. The original stock, a Banksian rose, was planted more than fifty years ago; but, at heights varying from ten to fifteen feet, grafts of Maréchal Neil, Marie Van Houtte, Devoniensis, Cloth of Gold, Madame Eugénie Verdier, and other choice varieties, have been inserted, and these have made wonderful growth. The trunk at the base is nearly a foot and a half in diameter; and the branches cover two trellises, each some forty feet long and twelve feet wide, besides rioting over a piazza sixty-five feet long and forty-five feet high, while the topmost shoots are aspiring to cover the roof. From a photograph it can be seen that this great vine was thickly covered from bottom to top with finely developed flowers.

— Our own missionaries in China frequently allude to cases of opium-poisoning, says *The Missionary Herald*. They are often summoned in haste to treat those who have by this method attempted suicide. Rev. Mr. Dixon, a missionary of the English Baptist Mission at Tai-yuen-fu, reports, that, during the three years he has been connected with the mission, he has attended

some thirty-six cases of attempted suicide by opium. He affirms that nine out of every ten men and women smoke the drug, beginning about twenty years of age, some of them earlier. The excess in this indulgence is such as to impoverish the people, and the poor wretches who are unable to obtain the supply they crave often end their sufferings by borrowing enough to destroy life. In Mr. Dixon's list of cases, there are young men and old men, girls and wives, beggars and officials. One of the occasions which frequently leads to this rash step is anger which has been excited by some trivial circumstance. Opium is an awful scourge in China, and brings in its train innumerable evils, of which, perhaps, opium suicide is not the worst.

— Four locomotives to be run by soda, which takes the place of fire under the boiler, have been built in Philadelphia, says the *Railway Age*, for service on the streets of Minneapolis, Minn., where steam-engines are forbidden. The engine is about sixteen feet long, entirely boxed in, with no visible smoke-stack or pipes, as there is no exhaust or refuse. The boiler is of copper, eighty-four and one-half inches in diameter and fifteen feet long, having tubes running through it as in steam-boilers. Inside the boiler will be placed five tons of soda, which, upon being dampened by a jet of steam, produces an intense heat. In about six hours the soda is thoroughly saturated, when the action ceases. A stream of superheated steam from a stationary boiler is then forced through the soda, which drives out the moisture, and the soda is ready for use again. The exhaust steam from the cylinders is used to saturate the soda, and by this means all refuse is used. These engines are the first of their kind that have been built in this country. They will have the same power as those used on the New York elevated roads. Soda-engines are used in Berlin and other European cities very successfully, and they also traverse the St. Gothard Tunnel, under the Alps, where the steam-engines cannot be used, because the tunnel cannot be ventilated so as to carry off the noxious gases generated by a locomotive.

— In 1864 a hot-headed French inventor offered to contract for churches and cathedrals, including a peal of bells, says *The Paper Makers' Circular*, to be constructed entirely of paper. From chimes to cannons was but one step, and the Gallic inventor announced his readiness to supply a train of artillery of any given caliber, made of the same material. Building-paper is enjoying a perfect boom just now, and is proving a fine material in the hands of architects and builders for several uses, inside and out. The advantages, briefly stated, are: continuity of surface, or its adaptability for making into rolls of almost any width and length, and flexibility; or by glueing several layers together it may be made stiff, and will stop the passage of air because of the absence of joints; unlike wood, it has no grain, and will not split; it is unaffected by change of temperature, and thus has an advantage over sheet-metal for roofing materials; though in its natural condition it is affected by moisture, it can be rendered waterproof by saturating with asphalt or by various other methods; being a non-resonant body, it is well fitted to prevent the passage of sound; it is a non-conductor of heat, and can also be made of incombustible material, like asbestos, or rendered resistant to fire by chemical treatment.

— The electrical census machine is described as follows in *The Engineering and Mining Journal*: "The census-collector will call with his printed blank, and answers to questions will be written in the usual way. These sheets will then be placed before a person who operates a machine which may be likened to a typewriter, except, that, instead of the usual ink-mark on paper, small round holes are punched in a card. The cards, one for each person, are about $6\frac{1}{2}$ inches in length by 3 inches in width, and the particular position of a hole in a card indicates an answer to some of the questions in the printed blank. As many as 250 items of information can be punched out upon a card, although no one card would ever have more than one-tenth part of the whole number: as, for example, no one person can be classed as both white and black, American and foreign born, and if foreign born he can only come from one country. These cards, when punched, are placed one at a time in a sort of press, and a lever operated by one hand is brought down, when a series of pins are brought against the

card. Whenever a hole has been punched in a card, the corresponding pin passes through into a mercury-cup beneath, completing an electric circuit. These circuits, one for every hole, pass out to a large number of counters which operate electrically, and which add upon their dials all items of the same kind upon the same dials: as, for instance, all white men upon a dial marked "white males;" all business or professional people, upon dials which indicate their particular business or profession. The cards, as they leave the press, are all sorted by means of an electrical sorting device, whereby they may be separated into groups or States of the Union. It will thus be seen that the machines are much more reliable than the most accurate human agency, and that one machine will do the work of a large number of clerks. The next census of this country will be taken with these machines, and two will be sent to New York soon for the 1890 census-taking."

—The report of the royal commission appointed to consider the expediency of establishing a teaching university for London has been laid on the table of the House of Commons, and *Nature* states that the Blue Book may be expected soon. The commissioners are agreed, first, that the petition of the Royal Colleges of Physicians and Surgeons to be authorized to grant degrees in medicine should not be entertained; second, that it is desirable that London should have a teaching university. On the third point — whether a charter shall be granted to the associated colleges of King's and University, constituting these colleges the Teaching University of London — the commission are divided. The three commissioners connected with the teaching profession (Sir William Thomson, Professor Stokes, and Mr. Welldon) are in favor of it; the three lawyers (Lord Selborne, Sir James Hannen, and Dr. Ball) are opposed to it. The report ends with a request that this question be referred back to the commission for their further consideration, in order that they may determine whether it is not possible to devise a scheme of common action between the two colleges and the existing University of London.

—The Swedish Government has decided, *Nature* announces, to send a man-of-war to New York to bring home the body of Capt. Ericsson, who expressed a strong desire to be buried at Langban-shyttan, in Vermeland, the place of his birth. In his will no directions are given as to the disposal of his valuable collection of models, but Swedish journals state that the executors will present them to the Smithsonian Institution.

—According to *Allen's Indian Mail*, the Madras Museum now possesses the skeleton of the largest elephant ever killed in India. This elephant was the source of great terror to the inhabitants of South Arcot, by whom it was killed and buried. The museum authorities despatched a taxidermist to the spot to exhume the bones and transfer them to Madras. The skeleton is exactly 10 feet 6 inches in height, being 8 inches higher than the highest hitherto measured in the flesh by Mr. Sanderson.

—The Upsala University and the Swedish Geographical Society have sent Dr. Carl Forsstrand to study the marine fauna of the West Indian Islands during the present summer.

—Mr. Chardonnet has succeeded in preparing a new artificial silk, — a silk which bears the same relation to the natural article as celluloid does to ivory. Its preparation is somewhat as follows: Cellulose (cotton, or whatever may be available), after being treated with a mixture of nitric and sulphuric acids in equal proportion, as for the making of gun-cotton, is dissolved in a mixture of alcohol and ether, to which is added some perchloride of iron or protochloride of tin and tannic acid. The solution thus obtained is placed in a vertical vessel terminating in a small tube or in a diaphragm pierced with fine holes, so that it can run out into a vessel full of water slightly acidulated with nitric acid. The fine fluid filament which comes out takes on immediately a more or less solid consistency, and forms a thread, which can be wound on a spool. The thread thus obtained resembles silk very closely, and is equally strong and elastic. It is not attacked by water, cold or warm, nor by the acids and alkalis moderately concentrated. By introducing into the solution coloring-materials, one may obtain threads of

any desired shade. This artificial silk is said to be extremely inflammable, — an objection which it is hoped to overcome. It is probable that the nitric acid can be replaced by some other which will render it less combustible. When this progress has been realized, we shall have a new textile fabric of the greatest importance.

—Madrid has for a long time shared with St. Petersburg and Buda-Pesth the monopoly of being one of the most unhealthy cities in Europe. From 1880 to 1887 the number of deaths averaged 41.2 per thousand. In 1887, on account of epidemics of scarlet-fever and diphtheria, this figure rose to 45 per thousand. As a result, the public and the authorities have been aroused, and the government has just ordered certain measures to improve the sanitary condition of the city, including improved drainage systems, methods of disinfection, the inspection of the food-supplies, the organization of proper hospitals, etc.

—Laura Bridgman, the famous deaf and blind mute, died May 24 in the Perkins Institution for the Blind in South Boston, of erysipelas, which finally attacked the heart. She had been ill for about three weeks, and retained her consciousness almost unto the last. The story of her afflictions, and of the wonderful way in which she was enabled to triumph over them, had made her name known throughout the civilized world. She was born in Hanover, N.H., Dec. 21, 1829, and, although subject to fits in infancy, was an intelligent and healthy child, with all normal faculties, at two years old. At that time she was prostrated by a fever, which raged for seven weeks, destroying sight and hearing, and blunting the senses of taste and smell. She did not recover her health for two or three years, and was cut off, necessarily, from all ordinary human communication, although she exhibited signs of intelligence, and proved her recognition of different members of her family by certain motions which she herself invented. She was seven years old when she was put under the control of Dr. Samuel G. Howe in the institution of which she remained an inmate for so many years, and her education was begun.

—A writer in the *Pall Mall Gazette* says, that, including five drowning cases, the fatal accidents from all causes in connection with the Forth Bridge amount to 53. As regards those killed in the actual construction of the bridge, there have been 44 lives lost, death taking place either at the time of the accident or soon after. The total number of accidents which had occurred up to September, 1888, — mostly in the four years beginning with September, 1884, — was 543, of which the greater part, of course, were of the description ranging from "serious" to "slight." Of these 543 cases, 84 were treated in hospital, and 459 at the homes of the injured persons. The following hair-breadth escapes are recorded: One man trusted himself to work at a height of 120 feet over the waters of the Firth, simply grasping a rope. His hands got numbed with cold, his grasp relaxed, he fell backwards down, and down, into the water; and he was fished up alive. In another instance a spanner fell a distance of 300 feet, knocked off a man's cap, and fell on the wooden stage at his feet, and went clean through a four-inch plank. In another case somewhat similar, a spanner which fell from a great height actually tore a man's clothes from his waistcoat to his ankle, and left him uninjured. One of the most thrilling incidents heard of was that in which the "staging," or scaffolding on which the men work high up in mid-air, gave way, carrying a number of poor fellows in its fall. Two of these men, striking some portion of the work in their descent, were killed before they reached the water; one or two others who fell clear of the girders were rescued from the Firth little the worse for their fall and immersion; two others, however, managed as they fell to grasp at one of the struts high up above the water, and there they clung for dear life. To effect their rescue was itself an undertaking of no slight danger; but efforts were promptly made, and before long the man who happened to be nearest the rescuer was reached. And this brave fellow, hanging there to the ironwork, actually persuaded the rescuers to delay taking him off before they saved his companion. "Never mind me!" he said: "I can hold a bit longer; go and see to my mate, for he's getting dazed, and he'll drop." We are glad to record that this hero, and his mate too, were saved.

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NOW THAT THE PARIS EXPOSITION is attracting a great crowd of strangers to Paris, it is not without interest to note the excellent sanitary condition of that city. The mortality has at no time this year reached so small a figure as in the week ending May 4. The average for this week in the past five years has been 1,122. This year the mortality was only 984; and in the week following, it fell to 951. Typhoid-fever especially has shown, since 1888, a constant decrease. More than all others, this affection belongs to the list of diseases which may be avoided; and it is only necessary that there should be due energy on the part of the public authorities to reduce its frequency in a notable proportion. While typhoid-fever and varioloid have decreased, it is unfortunate to note that this is not true of measles and of diphtheria. This results, no doubt, from the fact that the measures which can stay the progress of these diseases depend more upon individual initiative than on public measures. Among the causes which may explain the improved health of Paris may be noted the increased use of the conveyances which are placed by the police at the disposal of those wishing to transport persons suspected of being affected with contagious diseases. In 1886 these carriages were called for only at the rate of thirty to forty per month. In 1888, in the month of April, this number had increased to 211; and in the April just passed, to 231. Another cause acting beneficially is doubtless the improvement in the quality of milk, — an improvement due to the constant control exercised by the city laboratory.

IN 1856, ISIDORE GEOFFROY-SAINT-HILAIRE, in a work of considerable importance on food-substances, and in particular on horse-flesh, wrote, "There are millions of Frenchmen who never eat meat, and each month there are millions of kilograms of good meat all over France turned over for industrial uses of secondary importance, or even thrown away." Since that time, and in a great measure as the result of the persevering efforts of Mr. Decroix, a retired military veterinarian, and to-day the honorary president of the Society for the Prevention of Cruelty to Animals in France, horse-flesh has entered in every part of France into every-day use. In Paris alone the number of horses slaughtered for food-purposes has risen since 1866 from 902 to 17,256 in 1888. The greatest consumption, as is well known, was during the years 1870 and 1871; but there has been a constant increase from 1872 on. In addition to the horses consumed, there are also a considerable number of asses and mules. From Paris the use of horse-flesh has extended into the provinces, and at this time there are in all the large cities of France slaughter-houses for the purpose. The animals are no longer allowed to die of disease or of old age after their usefulness as beasts of burden has come to an end, and it is claimed that a horse twenty years old in good condition is more tender than a young one if thin and hard-used. In the Department of the Seine alone, on the 1st of January, there were 132 establishments for the slaughter of horses. The price of horse-flesh is but little more than half of that of beef for the corresponding parts; and it is claimed by Mr. Decroix that horse-flesh is more healthy and more nourishing than that of beef, and that, in equally good condition, five pounds of beef are required to give the same amount of nourishment as four pounds of horse-flesh.

BAKING-POWDERS.

HENRY B. CORNWALL, Ph.D., professor of analytical chemistry at the John C. Green School of Science, Princeton College, has, during the past year, made analyses of the different brands of baking-powders sold in New Jersey, in order to determine their ingredients, the leavening power or strength of each, and the healthfulness or otherwise of the residues left in the bread after baking. A full report of the results will be found in the "Report of the Dairy Commissioner of New Jersey for 1888." Professor Mallett of the University of Virginia has recently completed an investigation of the baking-powders in general use, and his results are reported in full in the *London Chemical News* of Dec. 7 and 14, 1888. The whole subject of baking-powders has therefore been very thoroughly examined into by two competent and disinterested chemists; and the advantages and disadvantages of the different brands duly set forth in their reports. The opinions given in the report of Professor Cornwall are based on some 55 analyses of 39 brands of baking-powders, as follows: —

	Analyses.	Brands.
Cream-of-tartar and bicarbonate-of-soda powders	13	8
Phosphate-of-lime and bicarbonate-of-soda powders.....	7	4
Alum, phosphate-of-lime, and bicarbonate-of-soda powders	26	20
Alum and bicarbonate-of-soda powders.....	6	4
Unclassified.....	3	3

Large quantities of inferior baking-powder were found to be sold in bulk by manufacturers. This is put up in boxes by the retailer, and a fancy label affixed, he knowing nothing about the composition of the substance, its cheapness only concerning him. During the time the samples from Professor Cornwall's analysis were being completed, it was ascertained that some of the makers and dealers in the inferior grades of baking-powders joined with their business that of lottery or gift enterprise; and plates, cups, lamps, pewter casters, and other household goods, were given away with a certain number of cans, or a can of baking-powder was given with a certain quantity of tea or coffee. It was stated in one sec-

tion of the State that one enterprising manufacturer offered a wagon with each purchase of a certain number of cans.

In commenting on this report of Professor Cornwall, the dairy commissioner, Dr. Newton, says that from inquiries made in various parts of New Jersey, and from knowledge gained in conversation with those conversant with the habits of all classes of people, he should say that the use of baking-powders is confined to the preparation of biscuits, cake, and articles other than bread. The biscuit thus prepared is usually eaten hot, and constitutes a very large portion of the dietary of the working-people. In the homes of many of the wage-workers, this biscuit made with baking-powder is the usual form of bread used for at least two-thirds of the time; fresh, yeast-leavened bread being the exception. This, of course, does not obtain in the large cities, where bread is easily bought. It may be said, without fear of contradiction, that bread made by means of yeast is by far the most satisfactory and the most healthful of all the preparations of flour. It contains no residue about which there can be any controversy, it contains no added chemical; it retains, with but little change, the nutritive elements of the flour. Hence, while baking-powders may answer for occasional use, they cannot be recommended as a complete substitute for yeast, as their action is different from and the product dissimilar to that obtained from fermentation.

A baking-powder should answer to all of the following requirements: 1. It should generate the maximum amount of gas; 2. It should contain no unhealthful ingredients; 3. It should leave in the loaf no unhealthful residue; 4. The elements should be combined in such proportions that the residue is neutral in re-action.

Dr. Newton further says that the evidence is conclusive, and certainly points to these facts: that alum residue does affect digestion, and that these residues are more or less soluble, and are carried into the system. Hence it is suggested, that, if any person wishes to avoid a possible danger to health, he should refuse to buy alum-powders. It must be stated, however, that the evidence in the case is not as strong as with other chemical agents, and we cannot speak of the results following the constant ingestion of small quantities of the soluble alum compounds with the certainty that we do when considering lead and other toxic agents, which are poisonous when taken in very minute quantities and continuously. All that he can do officially, while there is yet doubt on this question, is to give the public the benefit of that doubt, and advise the use of these preparations with great caution until the problem is positively settled by experiments on the lower animals. As will be seen by reading Professor Cornwall's paper, some alum combinations are known to be dangerous to health: these he has indicated. He cautions the public that baking-powders sold by weight, and without any name on the package, are to be avoided, as any manufacturer responsible for his preparations will not be ashamed to print his name on the label.

In the introduction to his report, Professor Cornwall remarks, that although nothing is so well adapted as yeast for making a palatable and digestible bread, yet their greater convenience or the necessities of the case may sometimes be a reason for using baking-powders even for making bread, and they are very largely used in preparing various articles of food which largely take the place of bread. It becomes, therefore, a very important question to determine the probable effects of the many different kinds of baking-powders on the health of the consumer.

He explains the action of baking-powders as follows: The baking-powders render the bread¹ light, through the action of gas set free in the dough. This gas is almost exclusively carbonic-acid gas, the carbon dioxide of the chemist. The carbonic acid is set free from bicarbonate of soda by the action of some acid substance, which yields a part or the whole of its acid to the soda, thereby expelling the carbonic acid.

Carbonate of ammonia has been to some extent employed. This substance is solid at ordinary temperatures, and is converted into gas by the heat in baking, but is not alone suitable for a baking-powder, because it may easily remain to some extent in the bread after baking, imparting to it not only an unpleasant taste, but possibly, even probably, unwholesome properties.

¹ For convenience, the term "bread" will be used to include any articles made with baking-powders.

Formerly the cook made the baking-powder, when needed, by mixing in due proportions the two salts commonly used, — cream-of-tartar and bicarbonate of soda. The cream-of-tartar (bitartrate of potash) contains more of the tartaric acid than is necessary to neutralize the potash in it, and this excess of acid liberates the carbonic acid from the bicarbonate of soda. The re-action takes place only when the two salts become dissolved in the dough, and these salts were especially adapted to the purpose because they dissolve but slowly; so that there is a continual and gradual liberation of the gas, keeping the bread light until the baking is finished. Bicarbonate of soda is better than simple carbonate, also, because it yields twice as much gas.

There were serious objections to the old-fashioned process. Apart from impurities in the salts, which are quite as prevalent in some of the modern baking-powders, the cook needed to exercise unusual care in measuring the two salts, so as to avoid getting too much of one or the other; and quite as great care was needed to thoroughly mix the two, so that they might exercise their full action on one another, without which the familiar yellowish or brownish "soda" spots would be produced. A really well-made baking-powder obviates all the evils resulting from these causes, as well as from the use of impure or deteriorated materials.

The requisites of a good baking-powder are (1) that the ingredients, in the quantities used, shall not injure the health of the consumer; (2) that the powder shall yield the largest amount of gas that can be obtained from wholesome ingredients, and in such a way as to produce the best effects (boiled with water, it should give a neutral or very nearly neutral solution); (3) that the powder shall keep its strength, and also not cake or become lumpy under the ordinary conditions of storage and use.

The caking of the powder is due to the fact that some of the active ingredients are often of such a nature as readily to absorb moisture from the air, so that they partly dissolve, and not only cause caking, but also loss of "strength" through the escape of carbonic-acid gas. This evil is greatly reduced by the use of well-dried materials, and by the addition of dry starch-powder, wheat-flour, or similar farinaceous substance, so that a well-made powder loses very little strength. In good cream-of-tartar baking-powders, about twenty per cent of such a "filling" body is often used. More than this is unnecessary, and simply lowers the cost of the product. A little less is sometimes used. In the majority of alum-powders the strength is only one-third or one-half what it might be; and in many cases this is, no doubt, due to excess of the starch or flour thus sold at the price of baking-powder. It may be argued that the strength of the powders is purposely kept down to a standard that will permit the use of the customary "two teaspoonfuls."

The statements on labels, that a powder "is made from pure ingredients," has little significance, unless the ingredients of the powders are also given. An alum-powder may be made of pure alum; a mixed powder may contain pure bisulphate of soda and pure tartaric acid; even an acid-phosphate-of-lime powder may be made of pure materials, so far as concerns the addition of any adulterant by the compounder, and yet the acid phosphate may be full of sulphate of lime, originally present in it by the nature of the process of manufacture. Thus, a maker of baking-powder might be sending out an article containing much *terra alba* (sulphate of lime); and yet, because he knew he had not put in any *terra alba* as such, he would claim that his powder was pure.

Cream-of-Tartar Powders.

The cream-of-tartar itself is a natural constituent of grape-juice, and probably no material has ever been devised for making baking-powders that is open to less objection than cream-of-tartar, unless possibly the acid phosphates.

Acid-Phosphate-of-Lime Powders.

The acid phosphate of lime (also called superphosphate of lime) has of late been much used in baking-powders, and there seems to be no physiological objection to its use. Indeed, it is claimed that its use restores to the finest wheat-flour the phosphoric acid which is so necessary to our health, and which has been in great part removed with the bran. Other acid phosphates have been to some extent employed, but the acid phosphate of lime far the most

widely. Unless properly prepared, the acid phosphate may not be so objectionable a substance. It is made by acting upon ground bones with sulphuric acid. The result is sulphate of lime and the acid phosphate of lime. If, now, the latter, which is freely soluble in water, is leached out, leaving the sulphate of lime behind, we have the acid phosphate in fit condition to be used. It is mixed with starch, dried, and brought into the market as a cream-of-tartar substitute. Frequently, however, the sulphate of lime is left with the acid phosphate, and will then bring about any ill effects that may justly be attributable to the sulphate. Moreover, unless the sulphuric acid used has been carefully purified, it may bring no inconsiderable quantities of lead, and even arsenic, into the baking-powder.

Bisulphate of Potash and Soda Powders.

Bisulphate of potash has been to some extent used in baking-powders. Its ready solubility would render it unsuitable for use alone; but, when used, it has probably been for the purpose of securing a more rapid liberation of carbonic acid at first. Used with bicarbonate of soda, it leaves a residue of sulphate of potash and sulphate of soda; and the sulphate of potash is a very objectionable substance, if present in any considerable quantity. Stillé and Maisch say of it, "Formerly used as a purgative. It is so in smaller doses than other salines. Its action is apt to be harsh and burning in the abdomen." The dose is one-fourth to one-half ounce.

The sulphate of soda (Glauber's salt) is also an active purgative, very little used in England or in this country for administration to human patients, but it is used in Germany very largely in place of our more commonly employed sulphate of magnesia (Epsom salts). The dose of sulphate of soda as a purgative is one-half ounce to one ounce, from which it appears that it is a much more active drug than Rochelle salt.

Bisulphate of soda has been used in baking-powders, in combination with other acid principles. Its action on bicarbonate of soda results in a residue of sulphate of soda. The effects of such a residue will be referred to under alum-powders.

Sesqui-Carbonate of Ammonia.

Carbonate of ammonia, used in small quantities, is perhaps unobjectionable; but probably, if any considerable quantity were employed, disagreeable physiological effects might be expected, irrespective of the unpleasant odor and taste that the ammonia compounds would impart to the bread, which always shows ammonia re-action, even when small quantities only were used in making it. The ammonia salts in general appear to be much more irritating and stimulating than the corresponding soda or even potash salts. Stillé and Maisch say of carbonate of ammonia, "It is irritant, and if long continued, even in doses which the stomach will tolerate, it impairs nutrition." In doses of five to ten grains, it increases the fulness and force of the pulse, and causes a sense of tightness in the head. It is a very powerful agent. The ordinary dose is two to ten grains. Evidently, such a substance needs to be used with care in preparing foods.

Alum Baking-Powders.

Of late years the alum baking-powders, being more cheaply made, have come into extensive use, and have met with considerable opposition on the score of qualities alleged to be injurious to the health. The alum used in this part of our country is now almost exclusively burnt ammonia alum; and, since the potash alum is more expensive, the same is probably true of alum baking-powders in general. The crystallized alums are less frequently employed, because they are too easily soluble; but they may be used in connection with the burnt alum, to secure at first a more rapid escape of carbonic-acid gas. The alumina is present in the bread, partly as hydrate and partly as phosphate of alumina, in case simple alum baking-powders are used. Where acid phosphates are also used in sufficient quantity, the alumina remains in the bread as phosphate.

Professor Mallett regards it as a fair conclusion that not only alum itself, but the residues which its use in baking-powder leaves in bread, cannot be viewed as harmless, but must be ranked as objectionable, and should be avoided when the object aimed at is the production of wholesome bread.

Tartaric Acid and Tartrates in Alum-Powders.

The makers of alum baking-powders sometimes add tartaric acid or bitartrates to their powder, either with or without the addition of acid phosphate of lime. This is doubtless done with the best intentions, either to secure a more rapid escape of carbonic-acid gas at the outset, or otherwise improve the powder. Such additions in the case of several samples have been found, but the presence of tartaric acid or tartrates in alum-powders is very objectionable. If added in sufficient quantity to otherwise pure alum-powders, they prevent the precipitation of the insoluble hydrate of alumina entirely when the powder is boiled with water, and they may render much of the alumina soluble in water even after the bread is baked. Without doubt, it would then be readily soluble in the digestive organs, producing there the effects due to alum or any other soluble aluminum compound. Not even the boldest advocates of alum-powders have denied the injurious tendencies of soluble aluminum compounds in the bread.

Acid Phosphates in Alum-Powders.

The addition of acid phosphate to alum-powders can only be regarded as an improvement, provided the acid phosphate is free from sulphate of lime, lead, or other objectionable substances, and the powders are put up in truly air-tight packages. Otherwise the deterioration leads to the use of larger quantities of the powder, and often with the result of introducing larger quantities of the alumina compounds into the bread.

Results of Analysis.

The following tables give the results of analysis of the samples, so far as was necessary to classify them and determine their "strength;" that is, the percentage of carbonic-acid gas. The cubic inches of gas are given from one ounce avoirdupois of powder, at a temperature of 60° F., and barometer at thirty inches.

I. Cream-of-Tartar Powders.—In this class are placed all powders giving re-actions for tartaric acid and potash, and free from the phosphates, alumina, and any considerable quantity of soluble sulphates. Ammonia was sometimes present, whether as sesquicarbonate or bitartrate was not determined. Free tartaric acid was found in one case. Its presence has no effect on the wholesomeness of the powder, nor has the small amount of ammonia in any case found. The writer's experience is that the powders free from ammonia compounds yield just as light biscuits, etc., as the others. As regards purity of materials, there seems little choice between the higher grades of these powders.

II. Acid-Phosphate-of-Lime Powders.—The first two of these were packed in tightly corked glass bottles, and contained enough starchy material to keep them from deteriorating in these bottles. The bread preparation consisted of two separate powders, each in a paper package. One was bicarbonate of soda; the other, acid phosphate of lime mixed with starch. The strength was determined on a mixture of the two in the proportions directed on the packages. The wheat-powder was put up in tin boxes, without starch or other filling. One sample was in excellent order; the other, much caked.

III. Alum and Phosphate Powders.—This class embraces powders showing ammonia, soluble sulphates, alumina, and phosphates, when tested as already described. Inasmuch as some of these powders showed considerable alumina in the simple water solution, a more detailed examination of them is recommended, for the reasons already given. The actual presence of acid phosphate of lime, or of any other acid phosphate, was not proven; but all contained some phosphate, and have therefore been classed as indicated, although probably in every case they were made with acid phosphate of lime. As already mentioned, the low grade of several is perhaps from deterioration, due to the presence of the acid phosphate in packages not sufficiently air-tight. Acid phosphate will not keep well when mixed with bicarbonate of soda, except in well-corked bottles. Tin cases are not tight enough. Many of these powders contained sulphate of lime, chemically equivalent to *terra alba*. This was, perhaps, in no case added as an adulterant, but was a part of the acid phosphate of lime used; the latter not having been separated from the sulphate of lime formed in its

manufacture. The presence of this sulphate of lime must be regarded as objectionable. None of these powders are as strong as they might be made, and most of them are very deficient in strength. Apart from questions of healthfulness, there can be no economy in buying some of these powders.

IV. Alum-Powders.—Here are classed the powders showing the same re-actions as the preceding class, but free from phosphates. All appeared to be ammonia alum-powders, but re-actions for potash and tartaric acid were not wanting among them. Only one of them begins to come up to the strength which a "straight" burnt ammonia alum-powder might have.

V. Unclassed Powders.—The composition of these is such as to present their coming under any of the previous heads.

I. Cream-of-Tartar Powders.

Analyst's Number.	Brand.	Carbonic-Acid Gas, Per Cent.	Cubic Inches Carbonic-Acid Gas, Per Ounce.	Remarks.
4	The Best.....	11.60	107.3	
5	Sea Foam.....	10.86	100.5	{ Yields a little ammonia and soluble sulphate.
23	Sterling.....	11.70	108.2	Yields ammonia re-actions.
29	Health.....	6.96	64.4	{ Final re-action of aqueous solution strongly alkaline.
50	Health.....	7.25	67.1	
39	None Such.....	12.64	116.9	
40	Cleveland's.....	13.27	122.7	Received in June.
43	Cleveland's.....	13.82	127.8	Received in November.
41	Royal.....	13.56	125.43	{ Yields ammonia re-actions. Received in May.
42	Royal.....	13.06	120.8	{ Yields ammonia re-actions. Received in November.
45	Price's "Cream".....	11.95	110.5	{ Received in May. Contains free tartaric acid.
53	Price's "Cream".....	12.20	112.9	Received in December.
	Average (8 brands).....	11.60		{ Excluding 29 and 50, average is 12.46 per cent of carbonic acid.

II. Acid-Phosphate-of-Lime Powders.

Analyst's Number.	Brand.	Carbonic-Acid Gas, Per Cent.	Cubic Inches Carbonic-Acid Gas, Per Ounce.	Remarks.
46	Horsford's Phosphatic.....	14.95	138.3	{ Received in August. In eight-ounce glass bottle.
54	Horsford's Phosphatic.....	14.01	129.6	{ In retail dealer's stock one year. A little gas escaped on opening the four-ounce bottle.
47	Rumford's Yeast-Powder....	13.51	125.0	{ Received in May. In eight-ounce glass bottle.
48	Rumford's Yeast-Powder....	13.89	128.5	{ Received in August. In eight-ounce glass bottle.
49	Horsford's Bread Preparation	15.39	142.4	{ Received in August. Bicarbonate of soda and acid phosphate put up in separate papers. The acid phosphate was not quite free from soluble sulphates
21	Wheat.....	15.62	144.5	In tin box; in good order.
52	Wheat.....	5.83	53.9	In tin box; much caked.

III. Alum and Phosphate Powders.

Analyst's Number.	Brand.	Carbonic-Acid Gas, Per Cent.	Cubic Inches Carbonic-Acid Gas, Per Ounce.	Remarks. (All give Ammonia Re-actions.)
1	Patapsco.....	8.32	77.0	
2	Washington.....	8.81	82.5	Received in May.
27	Washington.....	9.97	92.2	Received in November.
3	Davis' O. K.....	8.99	83.2	
7	McDowell's G. & J.....	9.70	89.7	
9	Lincoln.....	9.73	90.0	
10	Kenton.....	7.01	64.8	{ Received in October. Another sample, received in May, gave 3.81 per cent.
11	State.....	6.70	62.0	Received in October.
15	State.....	8.42	77.9	Received in May.
13	On Top.....	9.17	84.8	
16	Perfection.....	5.09	47.1	{ In paste-board box with tin ends.
19	Silver Star.....	9.51	88.0	
24	Our Own.....	10.47	96.8	
35	White Star.....	10.09	93.3	
28	Somerville.....	8.39	77.6	
30	Grape.....	10.02	92.7	
31	Sovereign.....	8.96	82.9	
32	A. & P. (Atlantic & Pacific)..	8.97	83.0	
33	Higgins.....	6.63	61.3	Received in September.
51	Higgins.....	11.30	104.5	Received in December.
34	Windsor.....	8.77	81.1	
37	Brooks & McGeorge.....	10.16	94.0	
38	Henkel's.....	10.24	94.7	
	Average (20 brands).....	8.97		

IV. Alum Powders.

Analyst's Number.	Brand.	Carbonic-Acid Gas, Per Cent.	Cubic Inches Carbonic-Acid Gas, Per Ounce.	Remarks. (All show Ammonia Re-actions.)
8	Miles' "Prize".....	9.63	89.1	{ Shows potash re-actions, and reduces silver abundantly.
20	Four Ace.....	10.31	95.4	
26	Feather Weight.....	9.63	89.1	
36	One Spoon.....	16.77	155.1	{ Two other samples gave respectively 15.35 and 16.73 per cent.

NOTE.—Since the rapidity with which a baking-powder gives off carbonic-acid gas in the cold varies with the ingredients used, it was deemed worth while to test some powders as follows: Forty-five grains (three grams) of each was mixed, with as little shaking as possible, with one-sixth ounce (five cubic centimetres) of water, and the volume of gas evolved in five minutes was measured.

Cleveland's yielded 49.6 per cent of its carbonic acid.
 Royal " 45.6 " " "
 Horsford's " 68.8 " " "
 A "straight" " 6.3 " " "
 burnt alum powder }

V. Unclassed Powders.

Analyst's Number.	Brand.	Carbonic-Acid Gas, Per Cent.	Cubic Inches Car- bonic-Acid Gas, Per Ounce.	Remarks.
6	Silver Prize.....	8.14	75.3	Shows potash and ammonia re-actions, and reduces silver abundantly. Contains a soluble alumina compound. Shows ammonia re-actions; contains much soluble sulphate and some free tartaric acid.
22	Orange.....	8.00	74.0	
18	Our Best.....	6.15	56.9	

Professor Cornwall says, in conclusion, "Our investigations show, that, while especially the higher grades of cream-of-tartar and acid-phosphate-of-lime powders are maintained at a quite uniform standard of excellence, the State is flooded, also, with many baking-powders of very poor quality, — cheap goods, poorly made. Of the thirty-nine brands examined, twenty-five contain alum or its equivalent, in the shape of some soluble alumina compound; eight are cream-of-tartar powders, with small quantities of other ingredients in several cases; four are acid-phosphate-of-lime powders; two belong properly under none of the above classes.

"With one exception, the powders containing alum all fall below the average strength of the cream-of-tartar powders, and in the majority of cases they fall much below the better grades of the cream-of-tartar powders.

"In the cream-of-tartar and the acid-phosphate-of-lime powders, no indications of substances likely to be injurious to health, in the quantities used, have been found.

"More evidence against the use of alum in baking-powders might have been presented, but it would have been of a similar nature to that which has already been given. In the writer's opinion, the presence of alum in baking-powders is objectionable, since, under certain conditions, it may exert an injurious effect on the digestion. The effects may not be very marked in the case of any individual consumer; but that they can be induced to a greater or less extent, seems to be well established.

"There appears to be ample ground for requiring that the makers of baking-powders should publish the ingredients used in their powders, in order that the consumer, who may justly have doubts of the desirability of using certain kinds, may be protected. At present the only guaranty of an undoubtedly wholesome and efficient article appears to be the name of the brand.

"Moreover, since it is quite possible to put up the baking-powders in such a way as to preserve their strength very thoroughly, and since it is evident that many makers fail in this respect, it would not seem unreasonable to require that baking-powders should not be sold unless they will yield a certain percentage of carbonic-acid gas. The bad effects of the 'heavy food' prepared with some of the baking-powders among our samples must certainly be felt by those who use them, and who are yet too ignorant to know where the trouble lies. It is for this class especially that nearly all legislation relating to securing good food and drugs is enacted.

"Since it is evident that some of the alum-powders are so prepared as to increase the extent of any injurious effect, owing to the mixture of ingredients whose combination cannot be justified on any grounds, it is recommended that a special and more thorough examination of such be made, with a view to preventing their manufacture."

THE MINERAL WEALTH OF BRITISH COLUMBIA.

IN 1877, Mr. George M. Dawson prepared, in connection with the Canadian Government Surveys for the Canadian Pacific Railway, a general note on the mines and minerals of economic value of British Columbia, which was published in the "Railway Survey Report" for that year, and was afterwards reprinted, with some

additions, in the "Report of Progress of the Geological Survey for 1877-78." Since that time great changes have occurred in respect to the aspects of mining in British Columbia, and important additions have been made to our knowledge of its mineral resources and geology. In view of these, and the increasing interest now manifested in the development of the natural resources of the province, and the numerous inquiries constantly received on that subject, it appeared to be desirable to place the available information respecting its mineral wealth in the hands of the public in a summarized form. With this object in view, Dr. Dawson began the revision of the publication first referred to, but soon found, that, in order to obtain a reasonably satisfactory result, it would be necessary practically to rewrite the whole. The work has in consequence assumed proportions larger than were at first contemplated, and now appears as "The Mineral Wealth of British Columbia" (Montreal, Dawson Brothers), with an annotated list of localities of minerals of economic value.

The object of this publication is twofold. It is, in the first place, intended to serve in some measure as an exponent of the mineral wealth of the province to which it refers; to provide an answer of a general kind to the inquiries now so frequently made on this subject; and to collect for this purpose, in a convenient form, brief summaries of the facts contained in the several official reports on the geological features of the province, with specific references to the pages in which they are treated of at greater length. In the second place, it is designed to place in the hands of the "prospector" or miner a convenient synopsis of facts, with a list of localities likely to be of interest to him. In the endeavor to carry out this second purpose, it has been considered advisable to add notes on such general principles, and to advance such suggestions, as, from the study of the geological features of the province (dating from 1874), appear to be of importance, and likely to be of service at the present time in guiding the search for or exploitation of its metalliferous deposits. In further pursuance of this object, some facts resulting from late practice and investigations in other mining regions are alluded to, and their application to the problems of development in British Columbia is briefly noted.

While the important developments now in progress in the province appear to call for the present publication, it is to be anticipated that within a short time any thing that can now be said regarding vein-mining will be relegated to a position of merely historical interest.

The province of British Columbia, with an area of 390,344 square miles, includes a length of over 800 miles of the Cordillera belt of the West Coast, — a region of mountains and of geological disturbance, which, in this part of its extent, between the Pacific Ocean and the elevated western margin of the Great Plains, has a breadth averaging about 400 miles. This great mountain region extends north-westward and south-eastward, and constitutes the effective cause which has produced the similar trend of the Pacific coast between the same parallels of latitude. It represents the northern continuation of the most important metalliferous area of the United States, essentially repeating its main orographic features, though presenting also some notable differences of a general kind, as well as many local peculiarities.

The Cordillera belt, in British Columbia, may be described as comprising four great mountain systems or principal axes of uplift and geological disturbance, which are, in the main, nearly parallel to each other and to the coast, — the Rocky, the Gold, the Coast, and the Vancouver ranges.

The Rocky Mountain range proper is the farthest inland, and has an average breadth, in its southern part, of about sixty miles, but is decreased near the Peace River to forty miles or less, and apparently loses its importance and regularity locally where cut through by the Liard, though recovering both still farther to the north-westward. Near the 49th parallel, several summits occur in this range which exceed 10,000 feet in height; but northward few attain this elevation till the headquarters of the Bow River are reached. About the sources of the North Saskatchewan and Athabasca, the range appears to culminate, and Mounts Brown and Murchison occur, with reputed heights of 16,000 and 13,500 feet respectively. Near the Peace, few summits exceed 6,000 feet, so far as known. Though more or less extensive snow-fields occur in many

places, true glaciers are found only about the heads of the Bow, North Saskatchewan, and Athabasca. Some of the valleys penetrating this range on the east are lightly timbered or in part prairie-like in character, but as a rule the mountains are thickly wooded wherever sufficient soil exists for the support of trees; and, owing to the greater rainfall on the western slopes of the range, the forests are there often very dense.

Crystalline schists and granite are scarcely known in any part of the Rocky Mountains between the 49th and 60th parallels, the ranges being built up chiefly of a great series of paleozoic rocks, extending from the Cambrian to the carboniferous, with a total thickness of more than 28,000 feet in the Bow River region. There are also, however, more or less isolated basins of rocks of cretaceous age, which rocks were evidently at one time continuous with those of the same age in the eastern foot-hills and Great Plains. In these basins, beds of bituminous coal and of anthracite are found. Deposits of copper ores and of galena are so far the most important metalliferous minerals discovered in association with the older rocks of this mountain system.

The south-western side of the Rocky Mountain range is defined by a very remarkable, straight, and wide valley, which can be traced uninterruptedly from the 49th parallel to the head waters of the Peace, — a distance of 700 miles or more. This valley is occupied by the upper portions of several of the largest rivers, including the Kootanie, Columbia, Fraser, Parsnip, and Finlay. Gold-placers have been found and worked at a number of points along this valley, and important discoveries of various ores are now being made in its vicinity near the Upper Columbia and Upper Kootanie. It is naturally adapted to become a main line of communication between the southern and northern portions of the province, near its eastern boundary.

The next mountain system to the south-west of the Rocky Mountains is referred to under the general name of the "Gold Range," though really a complex and somewhat irregular mountainous belt, which includes several more or less distinct and partly overlapping ranges. The Purcell, Selkirk, and Columbia¹ ranges constitute its southern part, while to the north it is represented by the Cariboo Mountains, and still farther northward — after an important interruption — by the Omineca and Cassiar Mountains. These mountains are, generally speaking, less rugged in detail than the Rocky Mountains, including extensive areas of high, rolling plateau country, and supporting in their southern and more massive portion numerous glaciers and wide snow-fields. The highest summit so far actually measured is Mount Donald, on the line of the Canadian Pacific Railway, 10,645 feet. The forests of the Purcell, Selkirk, and Columbia ranges are dense and tangled; and these mountains are much more difficult to traverse, and even less perfectly explored, than the corresponding portion of the Rocky Mountains. Granites and crystalline schists of great age are abundant in the Gold Range, together with great masses of paleozoic rocks, respecting the structural relations of which very little is as yet known.

The Gold Range, as a whole, doubtless constitutes the most important metalliferous belt of the province. The richest gold-fields are closely related to it, and discoveries of metalliferous lodes are reported in abundance from all parts of it which have been explored. The deposits already made known are very varied in character, including highly argentiferous galenas and other silver-ores and auriferous quartz veins.

Between the Gold and Coast Ranges lies a region, which, for purposes of description, has been named the "Interior Plateau of British Columbia," having an average width of one hundred miles and a mean elevation of about 3,500 feet. Its height, on the whole, increases to the south; while northward it falls gradually toward the group of large lakes and the low country about the head waters of the Peace. This has, over a considerable part of its area, been covered by widespread flows of basalt and other volcanic rocks in the later tertiary period. It is now traversed in various directions by a system of deep, trough-like valleys of erosion, generally occupied by streams and rivers. Water standing at an elevation of three thousand feet above the present sea-level would flood most of these, and would divide its surface into a number of

islands, while a large tract of country about the 53d and 54th parallels of latitude would be completely submerged. In some places the plateau is pretty level and uniform, but many portions of it attain an elevation much exceeding the mean above stated; and it is usually only when broadly viewed, and in contrast with its bounding mountain ranges, that its character as a plateau is apparent. Its main area is practically closed to the north, about latitude 50° 30', by the ends of several intercalated mountain ranges, in which many of the summits attain a height of 8,000 feet. Nearly coincident with the 49th parallel is a second transverse mountainous zone, formed in the same way, the only orographically important gap in which is that found in the vicinity of the Okanagan River. The southern portion of the Interior Plateau includes much open country, constitutes the best grazing region of British Columbia, and affords, besides, some good agricultural land. To the north, with increasing moisture, it becomes generally forested, but embraces large areas which are suitable for eventual agricultural occupation.

The tertiary rocks of the Interior Plateau hold in many places beds of lignite or of coal. Where not concealed by the later rocks, the formations preponderantly represented belong to the paleozoic age. These include very notable developments of materials originally volcanic in origin. The geological structure is scarcely less complex than that of the mountain regions, and much yet remains to be done toward its elucidation. The Interior Plateau also presents some important granitic areas, and, particularly toward its south-western border, limited basins of cretaceous rocks. As a metalliferous region, it is destined to take high rank, particularly, it is believed, in respect to the precious metals, though its ores are too varied in character to admit of description in a few words. Placer deposits of gold have been worked in a number of widely separated localities, and platinum is abundant in the Similkameen region.

The Cascade Range of Oregon and Washington is largely composed of erupted volcanic materials, to which its characteristic features are due, though these materials rest upon a basis of older rocks. Its course is north and south, and it is definitely terminated in the vicinity of the international boundary. Near the mouth of the Fraser River its place is taken by a new mountain system, geographically and geologically distinct, in the composition of which volcanic ejectamenta play no prominent part. This forms the third member of the Cordillera in British Columbia, and, under the name of the "Coast Ranges," pursues a direct north-westward course for over 900 miles, forming throughout this distance the bordering mountain-zone of the continent. The Coast Ranges have an average width of about one hundred miles, and consist of numerous constituent ridges and minor mountain-axes with varied trends, frequently separated by deep parallel and transverse valleys. The average altitude of the higher summits is between 6,000 and 7,000 feet, while some exceed 9,000 feet. Glaciers are of frequent occurrence, and large in size, in the northern portions of the Coast Ranges. The mountains are, as a rule, densely forested and extremely rugged, the flora of their seaward slopes being that characteristic of the West Coast, and co-ordinated with its great humidity, while on north-eastern flanks the forest resembles that of the inland ranges.

Geologically the Coast Ranges owe the greater part of their elevation to a period later than the cretaceous, of which formation patches are found in them at great heights. The rocks consist chiefly of gray granites and granitoid materials, with which are associated gneisses and other crystalline schists, as well as paleozoic rocks resembling some of those of the Interior Plateau. In association principally with the last-named rocks, gold-placers occur locally. Copper and iron ores are frequently found, and rich silver ores have been discovered.

The name "Vancouver Range" may be applied as a general one to the fourth great mountain-axis, which, in a partially submerged condition, appears in Vancouver and in the Queen Charlotte Islands, and is continued southward nearly to the Columbia River by the Olympian Mountains of Washington Territory. The islands of the Alaskan archipelago have, on the map, the appearance of constituting a northern continuation of the same mountain system; but they may be more appropriately regarded, from an oro-

¹ The name "Gold Range" is often specially applied to that here spoken of as the Columbia Range.

graphic point of view, as forming a partially submerged lateral expansion of the Coast Ranges. The highest mountain of Vancouver Island — Victoria Peak — reaches an elevation of 7,484 feet, while there is a considerable mountainous area in the centre of the island which surpasses 2,000 feet in average altitude. Several summits in the Queen Charlotte Islands exceed 4,000 feet.

The Vancouver Range, while still to a considerable extent formed of crystalline rocks like those of the Coast Ranges, is principally composed of stratified rocks of paleozoic and triassic age, and is flanked in places, both on Vancouver and on Queen Charlotte Islands, by cretaceous rocks, which are here important because of their coal-bearing character. The areas underlain by these rocks are in general comparatively low, and hilly rather than mountainous; while a large tract of level land, based upon the tertiary formation, occurs in the north-east part of the Queen Charlotte Islands. Gold-placers have been worked in several places on Vancouver Island, but few ever attained much importance. Iron, copper, and lead ores and gold-bearing quartz are also known to occur in connection with this mountain-axis; but up to the present time the coal deposits have proved to be vastly its most important feature.¹

The general correspondence of that portion of the Cordillera belt included in British Columbia with that of the western portion of the United States, in some parts of which mining operations of the first importance have been in progress now for many years, has already been alluded to. No feature of the geology of the continent is more remarkable than the general persistence of certain zones of similar rocks in a direction coincident with that of the Cordillera itself, — a circumstance in part due to the original similarity in conditions of deposition of sediments, and in part to their equal participation, at a later date, in changes produced by like metamorphic agencies. The similarity thus observed, in a series of geological zones parallel to the general direction of the Pacific coast, is here more striking than the continuity of the constituent orographic uplifts of the mountain-belt, and contrasts very markedly with the diversity of rock-formations found to occur where this belt is crossed at right angles. While metalliferous deposits individually are inconstant, and even the best defined lodes can be followed, in the vast majority of cases, for but a moderate distance, their character is found to depend fundamentally upon that of the enclosing or adjacent rocks, in which, under the required local dynamic and other agencies, these deposits are found to recur with nearly identical features. It is not intended here to discuss the resemblances and differences of the various rock series met with in the corresponding region in the Western States with those of British Columbia; but it may be mentioned that the metalliferous districts of the province may with advantage be compared by the miner with those which have already been more fully developed in each corresponding portion of the Cordillera region to the south, and that from such rational comparisons useful indications may be derived in the present early stages of the development of the mines of British Columbia.

The Rocky Mountains proper, as previously defined, can scarcely be traced southward, with identical characters, farther than the main head waters of the Missouri, beyond which the eastern ranges of the Cordillera become more lax and irregular. The Gold Range may, however, be followed farther in a southerly direction, being continued by the Cabinet, Cour D'Alaine, and Bitter Root Mountains for about 300 miles. The Interior Plateau of British Columbia represents the Great Basin of Utah and Nevada, and the Great Plains of the Columbia, and combines to some extent the features of both; though differing markedly from the first in the fact that it is not here self-contained as to its drainage, and from the second in the diminished importance of its tertiary lava-flood. It has already been stated that the Coast Ranges of British Columbia are not continued to the south of the international boundary. They resemble the Sierra Nevada more closely than they do the Cascade

Mountains of Washington Territory and Oregon, and hold a similar relation to the interior basin with that held by the Sierra. While, however, the Sierra owes its elevation to a time immediately antedating the cretaceous, the main uplift of the Coast Ranges of British Columbia occurred at or after the close of that period. The Vancouver Range, again, dating from the same period with the last, is not traceable south of the Columbia River, beyond which, in Oregon and California, the Pacific is bordered by a range of coast-hills, which, from a geological point of view, are of very recent origin.

In California the principal auriferous territory coincides with the run of a certain belt of slaty and schistose rocks, which occurs on the western flank of the Sierra Nevada; these rocks being referred, by their contained fossils, to the triassic and cretaceous divisions of the geological scale. In British Columbia, while rocks of triassic age are largely developed, and in some cases with characters identical with those of the Californian gold-bearing rocks, no such persistent belt of these rocks is found in connection with the Coast Ranges, where (from what has just been said of the resemblance of the two mountain systems) it might, from analogy, have been sought for. While local occurrences of rich gold-placers are known, in association with slates probably of triassic age, on both sides of the Coast Ranges, the main auriferous territory in the province is found to align itself on the Gold Range; and the original deposits of gold, from which the placers have been supplied, are already known to exist in different series of rocks widely separated in age, and ranging all the way from the triassic to the Cambrian. While, therefore, there is no single well-developed gold-producing region, as in California, the area and mass of the rocks throughout which deposits of gold may be hopefully looked for are here greatly increased. The circumstances would also warrant the belief that the mode of occurrence of gold in its original matrix might differ from that found to the south, and in particular that this might be more varied. So far as investigation has gone, such a belief appears to be well grounded, and it would seem that to a very considerable extent the natural laws of this mining-field must be worked out independently.

In correspondence with the absence of the tertiary coast-hills of California, in which, under peculiar conditions of mineralization, the cinnabar ores of that State are developed, it is observable that in British Columbia no really important deposits of mercury have yet been discovered. It is by no means improbable that mercury ores may yet be developed in the province; but, if so, it cannot be in any continuation of the Californian cinnabar belt, and the conditions of such deposits may be expected to prove unlike.

Another and very important point of diversity is found as respects the cretaceous rocks of the southern and northern coast regions. In California and Oregon the mineral fuels which have been found and worked are lignites of tertiary age and of an inferior value. Similar fuels are known on the coast of British Columbia: but the rocks of the cretaceous here assume the rôle of a coal-bearing series, and yield coals of excellent quality, which more than hold their own in competition with all other fuels employed on the Pacific.

Still another noteworthy circumstance of difference, and one which is applicable to practically the entire area of the province when it is contrasted as a whole with the Pacific States, is that which has been produced by the general spread and movement of ice over this region during the glacial period. The changes thus effected in the distribution of surface materials, and directions of drainage, have most important bearings on the question of placer mining. They have also encumbered the surface of considerable tracts with "drift" deposits, which, while tending to produce a more fertile soil, largely conceal the indications to which the prospector generally trusts in more southern latitudes. At the same time, a great part of the oxidized upper portions of metalliferous veins, together with the atmospherically decayed country-rock associated with these, has been removed; thus often obscuring the outcrops of such veins, which would otherwise be well marked, and in the treatment of certain classes of ores rendering it necessary to begin work from the first with machinery and processes which in some other regions are only required after considerable depths have been attained.

¹ In connection with the foregoing outline of the ruling physical and geological features of the province, it should be stated, that while these features are moderately well known in the southern portion of the province, and as far northward as the 56th degree of latitude, and while in connection with the Yukon expedition some accurate information has been obtained for the extensive northern portion, there yet remains a large region, chiefly included between the 56th and 58th parallels, which, though touched upon here and there by the gold-miner, is yet almost unknown geographically and geologically.

These conditions, brought about by action during the glacial period, are among those which, in Dr. Dawson's opinion, have most tended heretofore to retard the development of metalliferous mining in British Columbia. Other circumstances which have operated in the same direction are, the densely wooded character of a great part of the country; the fact that the rivers are suited for navigation only in detached reaches; the remoteness from the coast of the richest and best-known placer-mining districts; and the cost of labor, supplies, and machinery, which may be regarded as in part concomitants, in part direct results, of these. Owing to the inaccessibility of the country, it has, till very recently, been prospected and exploited by the placer-miner alone, who has been deterred by no difficulty from reaching the most remote spots in which rumor, or reasoning of his own, lead him to expect the existence of the precious metal. Little knowledge or effort was expended in the search for metalliferous veins. Many such deposits supposed to be of value, were, it is true, located, and time and money which could ill be spared often uselessly spent upon them, leading only to discouragement. Even where the indications met with were altogether favorable, the original discoverer generally found that the capital and knowledge required for their development were not at his command, and it was difficult to interest those capable of dealing with such mines in a region which they could not easily visit and become familiar with at first-hand. With regard at least to the whole southern portion of the province, however, all this is now happily changed.

While speaking of causes which have hitherto stood in the way of vein-mining, it must also be mentioned that not the least important of these has been, and still is, the fictitious or exaggerated value too frequently placed upon entirely undeveloped discoveries. While it is manifestly right that the discoverer should be properly remunerated, it should be remembered that a mere surface showing, however promising, generally requires the expenditure of a large sum before its true value can even be ascertained, and that till thus developed it is unreasonable to expect a large payment for any mining claim.

In preceding paragraphs particular attention has been drawn to certain notable differences between the better-known and more fully developed regions of the southern part of the Pacific slope and those of the province of British Columbia, chiefly as a note of caution against the rash assumption of complete uniformity in conditions too often made without due investigation. The salient fact of the general identity of the structural features of the Cordillera region south and north, however, remain, and is such, that from this alone, even without taking into consideration the numerous and important discoveries already made, we should be justified in predicting an eventual great development of metalliferous mining in the province. It has already been stated that British Columbia includes a length of over 800 miles of the most important metalliferous belt of the continent; and, adding to this the northern extension of the same belt beyond the 60th parallel, we find that within the boundaries of Canada its entire length is between 1,200 and 1,300 miles. This, as has elsewhere been noted, is almost precisely equal to the whole length of the same region included by the United States from the southern line of Canada to the northern boundary of Mexico; and Dr. Dawson, after having enjoyed exceptional opportunities of investigation, feels no hesitation in recording his belief that the northern moiety of the Cordillera will ultimately prove to be susceptible of a development corresponding in importance to that which has already been attained in the southern.

British Columbia first rose from the position of a fur country to the rank of a colony, on the discovery of gold upon the Lower Fraser in 1858. Its subsequent history for a number of years is substantially that of the sudden rise and subsequent slow decline in importance of placer gold-mining. Coal-mining has, however, concurrently advanced, slowly but steadily, till it has obtained its present pre-eminent position. Such historical facts as appear to be important to the appreciation of these industries are touched on later in connection with them. With respect to vein-mining proper, we have as yet to chronicle merely the first steps; but in the southern part of the province the completion of the Canadian Pacific Railway has at length afforded the necessary impetus in this direction, and it is very gratifying to find, as an immediate

consequence, that this part of the country is rapidly beginning to prove its valuable character, and to justify the confidence which those best able to form an opinion on the subject have always felt and frequently expressed. Every thing which has been ascertained of the geological character of the province as a whole, tends to the belief, that, so soon as similar means of travel and transport shall be extended to what are still more inaccessible districts, these also will be discovered to be equally rich in minerals, particularly in the precious metals, gold and silver. In the southern district, for which information is most complete, praiseworthy efforts are now in progress, at a number of widely separated localities, toward the exploitation of ores, which, in many cases, have already been proved to be of an exceptionally valuable character. Here, at least, there is every reason to believe that we are on the point of witnessing the inauguration of an era of mining activity of the most important kind.

AMONG THE PUBLISHERS.

THE *Journal of Morphology* for June, being the first number of Vol. III. (Boston, Ginn), contains the following articles, besides eight lithographic plates: "The Actiniaria of the Bahamas," by Playfair McMurrich; "Contributions to the Osteology of the North American Passeres," "Notes on the Anatomy of Speotyto," by R. W. Shufeldt; "Variation of the Spinal Nerves in the Caudal Region of the Domestic Pigeon," by James I. Peck. The second number, that for August, will contain "The Mechanical Origin of the Structures of the Hard Parts of the Mammalia," by E. D. Cope; "The Embryology of Blatta and Doryphora," by William M. Wheeler; besides numerous cuts and seven lithographic plates. For the third number, the "Embryology of Linnbricus," by E. B. Wilson, is promised, and a paper by William Patten, dealing with the general embryology, including the segmental sense-organs, of arthropods. This number will probably be issued in October. A fourth number will probably be given with this volume, but its contents cannot be definitely stated. The subscription price is nine dollars for the volume, whether including three numbers or four.

—We have just received the first part of Vol. I. of the new "Century Dictionary," published by The Century Company, New York. This number appears in a unique and attractive binding, embracing the letters from A to Appet, and will be a welcome addition to the library. The work will be completed in six volumes of four parts each.

LETTERS TO THE EDITOR.

Fog.

A GREAT deal of discussion has recently taken place on the properties of fog and its causes. One writer attributes the celebrated London fog to the cooling of the air by radiation from hill-sides near the city, which air, flowing down, envelops the city. It has also been suggested that a cool northerly wind on the west side of a storm flows into the saturated air on the south side, and condenses fog. Again, over Newfoundland it is thought that a saturated current flows from the southward to cooler waters, often having ice floating in them, and thus produces fog. The objection to the first theory is, that the cause assigned could not develop a fog 500 or 1,000 feet thick. In the second case it seems plain that the cool north wind is always dry, and would quickly render the air unsaturated. In the last case, while the cause assigned might produce a fog just at sea-level, yet this would hardly be extensive enough, and it is probable that a calm is essential in fog-production.

Fog, it is admitted, is simply cloud composed of water-dust or solid minute spheres of water from $\frac{1}{100000}$ to $\frac{1}{1000000}$ of an inch in diameter. It is supposed by some that a dust-particle must be a nucleus for each sphere. When we consider the billions of such spheres in a cubic inch of fog, we may well halt, and demand that the moisture in a few cubic feet of fog be evaporated, and the trillions of dust-particles massed under a microscope, where they certainly ought to be visible. The laboratory experiments advanced to prove this theory seem entirely inadequate, when we consider the extreme improbability of such an hypothesis.

It would seem as though our views as to the condensation of these fog-particles, and consequent liberation of latent heat, must be very much modified. We are told that moist air, say, at 99 per cent relative humidity, has different properties from saturated air at 100 per cent. The first, by theory, has a diminution in temperature of one degree in 188 feet vertical height; while the second, at 80°, has a diminution of one degree in 500 feet. It does not seem possible for such enormous differences to exist in two masses of moist air so near alike. It is supposed that dry air has a capacity for molecules of vapor without change of volume, and dependent entirely upon the temperature. For example: a cubic foot of dry air weighs, at sea-level, 566 grams; the same saturated will weigh 571 grams at 56°, and 576 grams at 77°. If it weighs 571 grams at 77°, we say it is half saturated. It would seem as though the arrangement of the molecules must be precisely the same in the latter case as when the humidity is 99.9 per cent or 100 per cent, except that they are in a condition, in the moister air, to unite more readily. It would be a great stretch of the imagination to consider that there is any marked difference in the condition of the molecules at 99.9 per cent and at 100 per cent.

Suppose we cool saturated air very slightly: all the molecules cannot remain as vapor, but some of them coalesce, as do globules of mercury when they touch each other. It would seem probable that if, as many admit, rain is simply the coalescing of a very great number of minute cloud-particles, we may extend the same action a step farther back, and consider that the original molecules also mechanically coalesce without setting free any latent heat. If this be so, there certainly is not needed any dust-particle as a nucleus for the mingling. We have now our air still saturated with vapor, and at the same time full of, say, double molecules of vapor. If we cool still more, the double molecules add others to themselves, and we finally have our fog or fog-particles floating in saturated air.

It has been thought that these particles (spheres) are kept in suspension very much as dust is, but this hypothesis seems untenable. Others have considered that each sphere is electrified, and repels every other sphere; and there is some color to this from the fact that a vivid flash of lightning overhead is often followed by a heavy and sudden downpour of rain. It seems probable that we

can extend this hypothesis still farther back, and regard each molecule as electrified. May not the coalescing of these molecules be dependent upon their electrical state as much as or even more than upon their cooling? The principal point to be borne in mind is, however, that the formation of fog and cloud is a purely mechanical process, unaccompanied by the evolution of heat. A striking proof of this was observed during an ascent of Greylock, in Massachusetts, on Dec. 15, 1883. At the summit the wind was blowing a whole gale, and the temperature was -7°, with the air saturated but perfectly clear. In a few minutes there were just barely perceptible little white particles upon the overcoat. In a very short time the aggregation of particles, absolutely invisible to the eye, had become completely white. On the trees the particles had massed nearly an inch thick. Another proof of this mechanical aggregation is found in making observations with Regnault's dew-point apparatus. It would be supposed that as the dew-point is reached there would be a uniform deposit of molecules upon the plate; but this is not the case, as there are spaces between the dew-particles. The effect is most noticeable when hoar-frost is beautifully deposited in very marked lumps, at temperatures below freezing.

The cause of fog seems briefly as follows: 1. It is essential that there be no wind. I do not mean that the wind does not blow the fog after it is formed, but there must be little or none while it is forming. 2. The sky must be clear. We often notice a cloudless sky after a fog is dissipated. On weather-maps, "fog" is entered as "fair," for, though not a particle of sky is visible, yet it is almost a certainty that the sky is clear. 3. The air must be saturated, or nearly so. It is very surprising how rarely the last condition occurs at inland stations. A relative humidity of 95 per cent has been noted in the air, in which rain is falling, and had been falling continuously for seventeen hours. This condition almost always can occur only to the south, south-east, or north-east of a storm. At nightfall, whenever these conditions combine, there is a rapid radiation from the earth to the sky, which speedily supersaturates the overlying air; and, after that, radiation from the upper surface of the fog continues the process, and extends the fog upward until the action ceases with the rising of the sun.

H. A. HAZEN.

Washington, D.C., May 24.

Publications received at Editor's Office,
May 13-25.

- BACIGALUPI, E. G. Immunity through Leucomaines. Tr. by R. F. Rafael, M.D. New York, J. H. Vail & Co. 170 p. 12°.
- CENTURY Dictionary, The. Vol. I. Part I. A-Appet. New York, The Century Co. 272 p. 1°.
- CHURCH, I. P. Mechanics of Engineering. New York, Wiley. 832 p. 8°.
- COUSINS, R. H. A Theoretical and Practical Treatise on the Strength of Beams and Columns. London and New York, E. & F. N. Spon. 170 p. 12°.
- GREAVES, J. Statistics for Beginners. London and New York, Macmillan. 170 p. 16°.
- GUIMPS, R. de. Pestalozzi: his Aim and Work. Tr. by Margaret C. Crombie. Syracuse, N.Y., C. W. Bardeen. 320 p. 12°.
- HAMBLETON, G. W. The Cure of Consumption. London, Ballière. 301 p. 12°.
- HAYES, P. S. Electricity and the Methods of its Employment in removing Superfluous Hair and other Facial Blemishes. Chicago, W. T. Keener. 128 p. 16°.
- JOHNSON, Laura Winthrop. Eight Hundred Miles in an Ambulance. Philadelphia, Lippincott. 131 p. 16°.
- PRÉVOST, L'Abbé. The Story of Manon Lescaut and of the Chevalier des Grieux. Tr. by Arthur W. Gundry. Chicago, New York, and San Francisco, Belford, Clarke, & Co. 310 p. 12°.
- ST. JOHN, E. A Postal Dictionary. New York, Evening Post. 94 p. 24°.
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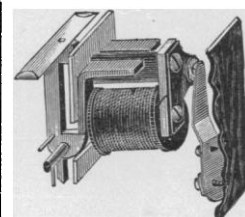
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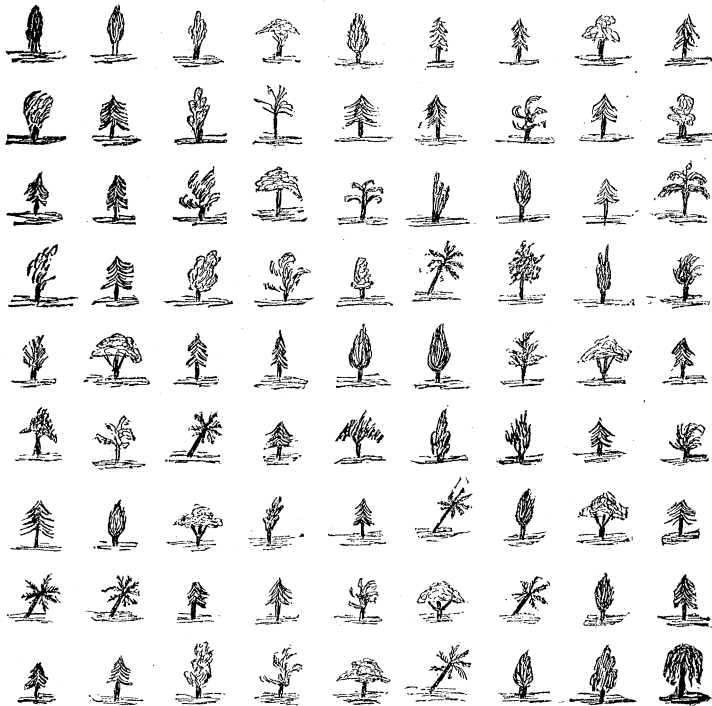
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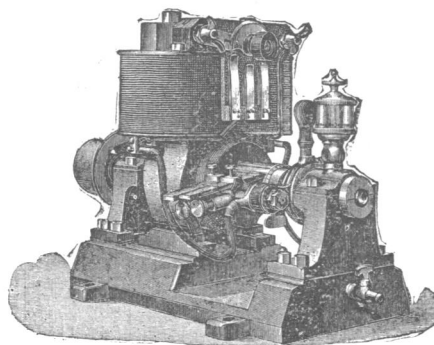
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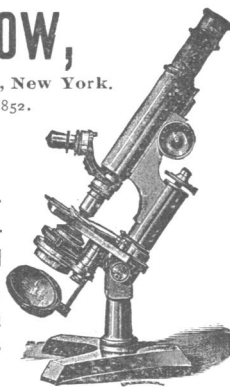
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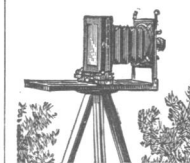
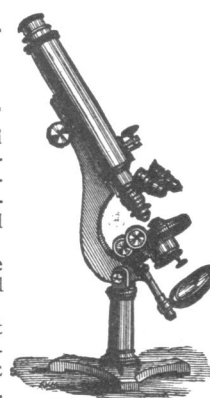
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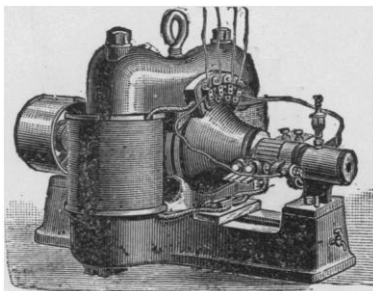
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